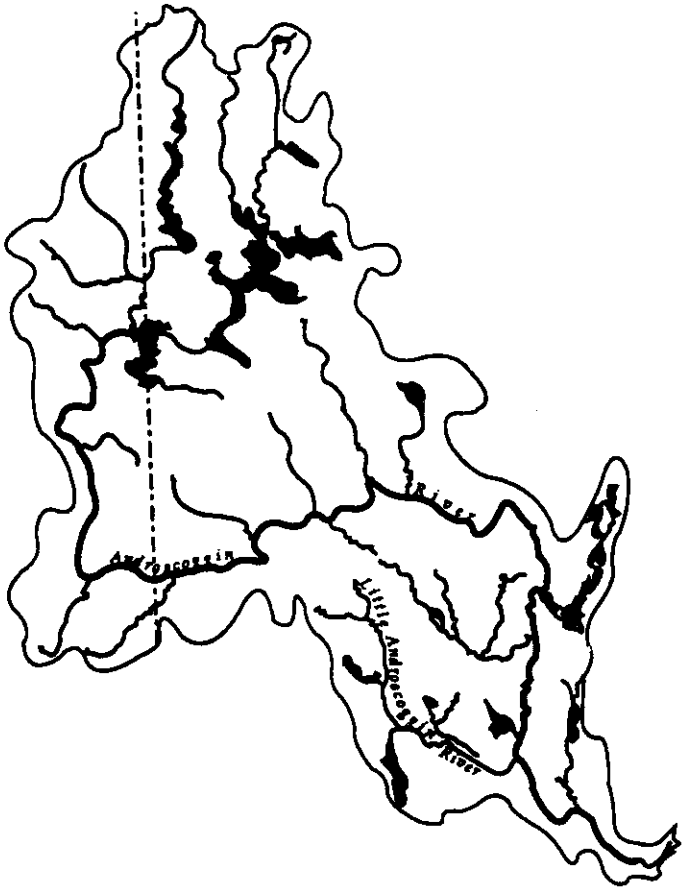
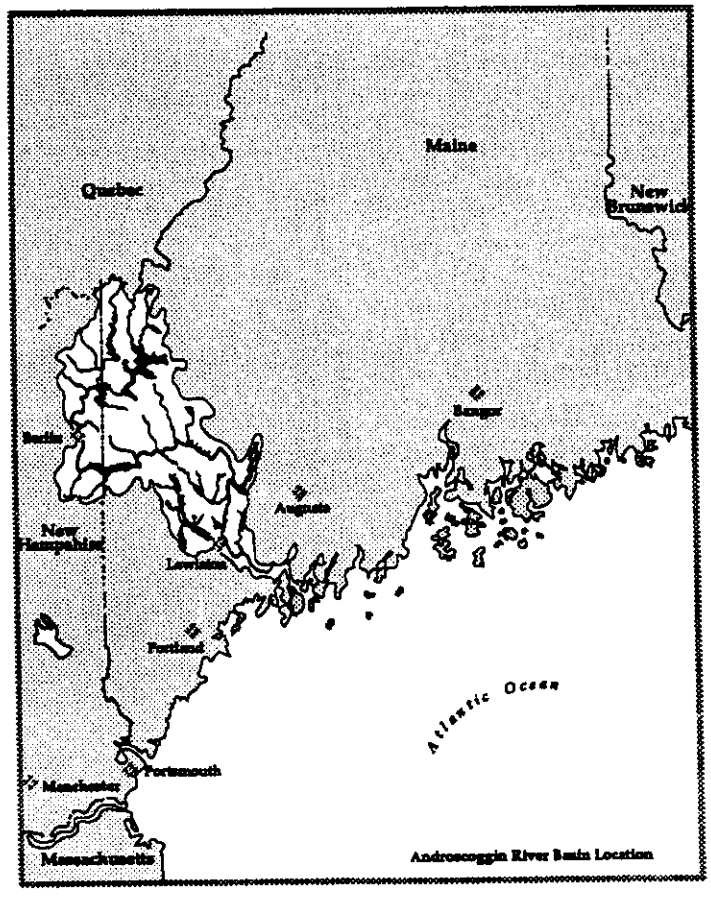
WATER RESOURCES STUDY

Androscoggin River Basin
Maine

Volume I

Androscoggin River Basin Study





March 1990

US Army Corps of Engineers
New England Division

WATER RESOURCES STUDY
ANDROSCOGGIN RIVER BASIN
MAINE

MARCH 1990

Department of the Army
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254-9149

EXECUTIVE SUMMARY

This report documents the results of a water resources investigation of the Androscoggin River Basin located in southern Maine and eastern New Hampshire. The investigation was authorized by a resolution of the Senate Committee on the Environment and Public Works, adopted 12 November, 1987. In accordance with the authorizing resolution, the investigation focused on determining the advisability of improvements in the interest of flood control, allied purposes, and related land resources.

The Androscoggin River Basin has a total drainage area of approximately 3,500 square miles, about 80 percent of which is in the State of Maine, and the balance in New Hampshire. The basin is bounded to the north by Canada and the Kennebec River basin, on the east by the Kennebec Basin, to the west by the Connecticut Basin, and on the south by the Saco and Presumpscot Basins. The Androscoggin River is confluent to the Kennebec River at Merrymeeting Bay, with the Kennebec discharging into the Atlantic. The reach of the main stem downstream of the dam in Brunswick, ME is tidally influenced.

The Androscoggin River is subject to frequent flooding, with three major events having been documented over approximately 50 years. Flooding usually occurs in the spring, as a result of heavy rains combined with snow melt. Most recently, a major flood occurred in the basin in March-April 1987. The 1936 flood continues to be the flood of record in the basin, with an intervening event in 1953 also being a major flood. Flood losses to Maine communities in the basin during the 1987 event were estimated by the State of Maine at $24 million. No significant damages were experienced by New Hampshire communities in this flood. This was principally due to the fact that the upper lakes had been drawn down to store spring runoff, and that major rains occurred over the mid-basin, downstream of the New Hampshire communities.

Due to the size of the basin and the number of communities along the rivers, an initial screening process was used in conjunction with the State of Maine to focus investigation on the areas which had the greatest likelihood of potential federal projects. The aforementioned screening process yielded eight communities; a ninth (Dixfield) was added since it was in the same damage reach. Damages in the communities selected account for over 90% of the total damages estimated by the State of Maine from the 1987 event. The communities selected are as follows:

Auburn	Lewiston	Peru
Canton	Lisbon	Rumford
Dixfield	Mexico	Topsham

Flood damage reduction alternatives formulated and evaluated to prevent or reduce flood damages were: flood control reservoirs, structural and nonstructural local protection projects, an automated flood warning system for the basin and reregulation of existing basin storage to reduce flood peaks.

The reservoir evaluation consisted principally of a reanalysis of sites identified and evaluated during a 1967 Corps Survey Report of the Androscoggin Basin. All of the sites which were economically infeasible at that time continued to be so. The one site (Pontook, in Dummer, NH) which showed economic promise in the earlier report, was found to be uneconomical in this study. No new reservoir sites were evaluated.

Local protection projects were also investigated in the nine communities selected for detailed plan formulation. A least cost dike alternative was used as a screening criterion, with cost per unit length being compared to physical distribution of the damaged (and protectable) structures. All communities except one (Rumford) dropped out in this screening. Rumford was further evaluated by locating and costing a flood control structure (dike). The project was not economically feasible.

Investigation of an automated flood warning system shows that it is economically feasible, with a benefit to cost ratio of 1.21 to 1. In addition, the precipitation and flow gages which are an integral part of such a system, may offer opportunities for reregulation of existing basin storage in the interests of flood control, hydroelectric power production, and water quality.

Nonstructural alternatives, including raising buildings and affixing closures were investigated for all damage centers. With the exception of one group of residential structures in Canton

TABLE OF CONTENTS

	Page No.
INTRODUCTION	
STUDY AUTHORITY	1
STUDY AREA	1
STUDY PURPOSE	2
PRIOR STUDIES	3
EXISTING PROJECTS	3
EXISTING CONDITIONS	
PHYSICAL RESOURCES	6
Watershed Description	6
Topography & Geology	10
Climatology	10
HYDROLOGIC CHARACTERISTICS	15
Streamflow	15
Floods of Record	15
Discharge Frequency	18
Stage Frequency	19
ENVIRONMENTAL RESOURCES	22
Water Quality	22
Biological Resources	22
Wetland Resources	28
Terrestrial Resources & Wildlife	31
Threatened and Endangered Species	34
HISTORIC & ARCHEOLOGICAL RESOURCES	35
Prehistoric Period	35
Historic Period	36
SOCIO-ECONOMIC RESOURCES	42
Population	42
Manufacturing	43
Agriculture	43
Recreation	43
Forestry	43
Transportation	43

PROBLEM IDENTIFICATION

EXISTING PROBLEMS 44
General 44
Effects of Upstream Storage 44
Flood Routing 44
Results of Flood Analysis 45

FUTURE CONDITIONS 46

STATEMENT OF PROBLEMS AND OPPORTUNITIES 46

PLAN FORMULATION

PLANNING CONSTRAINTS 47
Policy Constraints 47
Environmental Considerations 47

ALTERNATIVES CONSIDERED 50
Structural 50
Nonstructural 50
Automated Flood Warning 50

EVALUATION OF ALTERNATIVES 51
Benefit Estimation Methodology 51
Flood Control Reservoirs 53
Local Protection Projects 56
Nonstructural Alternatives 60
Automated Flood Warning System 69
Reservoir Reregulation 70
Summary of Economic Analysis 70

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS 72

RECOMMENDATIONS 73

LIST OF TABLES

Table No.	Description	Page No.
1	Available Basin Storage	4
1a.	FERC Licensed Sites in Androscoggin Basin	5
2	Androscoggin River and Tributaries	7
3	Monthly Temperatures	12
4	Monthly Precipitation	13
5	Monthly Snowfall	14
6	Streamflow Records	16
6a	Major Flood Flows - Androscoggin River Basin	17
7	Elevation-Frequency Data	20,21
8	Distribution of Fish Species in Rangely Lakes	24
9	Wetland Plants in Androscoggin River Basin	29
10	Important Species of the Northern Hardwoods Region	32
11	Population - Androscoggin River Basin - Major Urban Areas	42
11a	Androscoggin River Basin Routing Coefficients	45A
12	Component Contributions to Main River Flood Peaks	45B
13	Recurring Losses	52
14	Annual Losses	53
16	Screening Results for LPPs (Dikes)	57
16a	Cost Summary - Rumford LPP (Dike)	59
17	Recurring Losses: Rumford, ME	62
18	Structural Improvement Plan: Rumford, ME	62
19	Nonstructural Improvement Plans: Rumford, ME	62
20	Recurring Losses: Mexico, ME	63
21	Nonstructural Improvement Plans: Mexico, ME	63
22	Recurring Losses: Peru/Dixfield, ME	64
23	Nonstructural Improvement Plans: Peru/Dixfield, ME	64
24	Recurring Losses: Canton, ME	65
25	Nonstructural Improvement Plans: Canton, ME	65
26	Recurring Losses: Lewiston, ME	65
27	Nonstructural Improvement Plans: Lewiston, ME	66
28	Recurring Losses: Auburn, ME	66
29	Nonstructural Improvement Plans: Auburn, ME	67
30	Recurring Losses: Lisbon, ME	67
31	Nonstructural Improvement Plans: Liston, ME	68
32	Recurring Losses, Topsham, ME	68
34	Benefits from Flood Warning System	69
35	Costs of Flood Warning System	70
36	Summary of Economic Justification	71

LIST OF PLATES

Plate No.	Description	Following Page No.
1	Basin Map	1
3-5	Androscoggin River Profile	9
6	Discharge Frequency Curves: Main Stem Androcoggin River	18
7	Discharge Frequency Curves: Tributary Watersheds	21
9a-c	Stage Frequency Curves	21
10	Maine Dept. of Inland Fisheries & Wildlife - Management Regions	22
11	March 1936 Flood Analysis	45
12	March 1953 Flood Analysis	45
13	March/April 1987 Flood Analysis	45
14	March/April 1987 Flood Storage	45
17a	Nonstructural - Typical Closure Panel	60
17b	Nonstructural - Bond Beams/Vertical Reinforcement	60
17c	Nonstructural - Typical Door Closure Panel	60
17d	Nonstructural - Typical Display Window Closure Panel	60
17e	Nonstructural - Typical Closure for Horizontal Openings	60
17f	Nonstructural - Closure Panel Assembly	60
18	Rumford, ME (Virginia Section) Damage Area and Dike Location	62
19	Mexico, ME, Damage Survey Area	62
20	Peru/Dixfield, ME, Damage Survey Area	63
21	Canton, ME, Damage Survey Area	65
22	Lewiston, ME, Damage Survey Area	66
23	Auburn, ME, Damage Survey Area	67
24	Lisbon, ME, Damage Survey Area	67
25	Topsham, ME, Damage Survey Area	68

APPENDICES

A. CORRESPONDENCE
B. HYDROLOGY & HYDRAULICS
C. HEC-1 BASIN MODEL
D. ENVIRONMENTAL

INTRODUCTION

STUDY AUTHORITY

The Androscoggin River Water Resources Investigation was authorized by a resolution of the Senate Committee on the Environment and Public Works, adopted on 12 November 1987 which states: "RESOLVED BY THE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS OF THE UNITED STATES SENATE, that the Board of Engineers for Rivers and Harbors, created under Section 3 of the Rivers and Harbors Act, approved June 12, 1902, be, and is hereby requested to review the Report on Land and Water Resources of the New England--New York Region printed in Senate Document Numbered 14, 85th Congress, First Session, with particular reference to the Androscoggin River and its tributaries, Maine, with a view to determining the advisability of improvements in the interest of flood control, allied purposes and related land resources."

STUDY AREA

The Androscoggin River Basin covers approximately 3,500 square miles in western Maine and northeastern New Hampshire from the border of Canada to tidally influenced Merrymeeting Bay (Figure 1). The mainstem Androscoggin River is 169 miles long from its source at Umbagog Lake in Errol, New Hampshire to its mouth at Merrymeeting Bay, descending a total of 1,245 feet in the 161 miles above tidewater. It has two steep drops, 240 feet in 2.5 miles in Berlin, New Hampshire and 180 feet in 1.6 miles in Rumford, Maine. From Umbagog Lake it flows generally southerly to Gorham, New Hampshire where it turns to flow easterly toward Livermore Falls. From Livermore Falls it again flows southerly to Merrymeeting Bay and the Atlantic Ocean.

The upper basin above Rumford is forested and mountainous. The basin below Rumford is less mountainous and contains more ponds and agricultural land. Elevations in the basin range from the 6288-foot Mount Washington in the headwaters to sea level at Brunswick where the river becomes tidally influenced.

The upper basin contains a number of reservoirs constructed for log driving during the 19th century and now used for hydropower production. Most notable of these lakes are Aziscohos Lake, Umbagog Lake, Upper and Lower Richardson Lake, Rangeley Lake, and Mooselookmeguntic Lake.

Flows in the Androscoggin River are regulated from the Rangeley Lakes, a series of modified natural lakes in the headwaters. The Rangeley Lakes include: Kennebago Lake, Rangeley Lake, Mooselookmeguntic Lake, Upper and Lower Richardson Lakes, Aziscohos Lake, and Umbagog Lake. Storage capacity of the lakes has been increased by outlet control structures, originally used for log drives in the late 19th century. The dams controlling these reservoirs are owned and operated by the Union Water Power Company (UWP), a subsidiary of Central Maine Power Company (CMP) and

the Androscoggin Reservoir Company (ARCo), comprised of several downstream water users, including CMP. There is currently hydropower generation at Aziscohos Dam and Errol Dam. There is a pending Federal Energy Regulatory Commission (FERC) proceeding to license Middle Dam (Upper Richardson Lake) as a storage project. Fish and wildlife mitigation measures are currently being developed at Middle, Aziscohos, and Errol dams under the statutory requirements of the FERC licensing process.

Spring runoff is captured in the Rangeley Lakes and released over the remainder of the year to provide for downstream water users. Flow releases are in accordance with an agreement between the owners of the storage reservoirs and downstream water users that has been in effect since 1909. The agreement calls for a constant flow of not less than 1550 cubic feet per second to be provided in the river at Berlin, N.H. and that the reservoir system be operated such that one third of the seasonal storage draw be from Aziscohos Lake, and two thirds from the other lakes. Water releases are used primarily for hydropower generation and industrial purposes. Although storage releases augment natural flows in the river, this does not necessarily result in fishery habitat enhancement, as demonstrated by instream flow studies recently completed at the Pontook Hydropower Project.

The Androscoggin River flows through many run-of-river hydropower projects at and below Berlin, N.H. There is no appreciable storage in the system until Gulf Island Dam, located just upstream of Auburn, Maine. Gulf Island Pond serves as a re-regulation reservoir for a number of downstream hydropower projects. It is operated in a weekly cycling mode with reservoir refill on the weekends. Studies to assess fish and wildlife impacts and develop mitigation measures are currently underway as part of the FERC relicensing process for Gulf Island Dam.

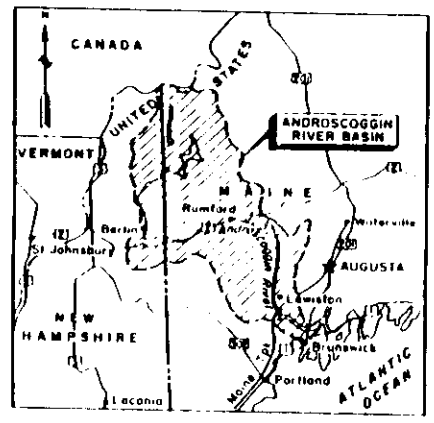
A number of tributary streams flow into the Androscoggin River over its length. The tributaries of greatest importance to this water resources study from upstream to downstream are Ellis River, Swift River, Webb River, Dead River, Nezinscot River, Little Androscoggin River, and Sabbatus River. These are potential locations of flood control structures considered for reregulation to control downstream flooding.

STUDY PURPOSE

This report defines water resources related problems and opportunities, identify potential structural and non-structural solutions, estimate benefits and costs of the alternatives and appraise Federal interest in the potential solutions. The study determines whether or not feasibility studies are appropriate and estimate their costs. Also, a preliminary determination is made of potential impacts on identified significant environmental resources within the study area.

PRIOR STUDIES

NENYIAC REPORT - A report by the New England - New York Inter-Agency Committee, (NENYIAC), was completed in March 1955. It contains a comprehensive study of overall water resource problems and opportunities in the Androscoggin River Basin and identifies potential management plans.



LOCATION MAP

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N

NEW HAMPSHIRE

MAINE

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LEGEND

▲ EXISTING USGS RECORDING STREAM GAGING STATIONS

BASIN SUB-DIVISIONS

Area	Description	Drainage Area in Sq Mi
A	Androscoggin River above Errol	1045
L_1	Local Area	170
L_2	Local Area	148
B	Moose and Peabody Rivers	95
L_3	Local Area	65
C	Wild River	69
L_4	Local Area	99
D	Sunday River	51
L_5	Local Area	22
E	Bear River	43
L_6	Local Area	32
F	Ellis River	163
L_7	Local Area	65
G	Swift River	129
H	Swift River plus Local Area	145
L_8	Local Area	323
I	Nezinscot River	181
L_9	Local Area	63
J	Little Androscoggin River	353
L_{10}	Local Area	173
	Androscoggin River above Brunswick	3430

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US ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS

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ANDROSCOGGIN RIVER FLOOD CONTROL

BASIN MAP

ANDROSCOGGIN RIVER, MAINE & N H

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CHIEF, PLANS & OPTS BRANCH

CHIEF ENGINEERING DIV

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SHEET 1 OF 1

PLATE 1

REPORT ON REVIEW OF SURVEY: ANDROSCOGGIN RIVER BASIN - A report by New England Division, Corps of Engineers, completed in 1967. The study investigated various structural alternatives for flood damage reduction, concluding "....structural measures for the reduction of flood damages in the Androscoggin River Basin are not warranted at this time."

FLOOD INSURANCE STUDIES - Flood insurance studies have been prepared by the Federal Emergency Management Agency for many communities in the Androscoggin River Basin.

STATE OF MAINE 1988 WATER QUALITY ASSESSMENT - This report was prepared by the Maine Department of Environmental Protection, Bureau of Water Quality Control. This biennial report to the U.S. Environmental Protection Agency describes the quality of its navigable waters.

STATE OF NEW HAMPSHIRE 1973 WATER QUALITY MANAGEMENT PLAN - This report was prepared by New Hampshire Water Supply & Pollution Control Commission, pursuant to PL92-500.

EXISTING PROJECTS

There are no projects in the basin operated exclusively for the purpose of flood control. There is a total of 725,300 acre-feet of useable reservoir storage in the Androscoggin River Basin, with 660,500 acre-feet (90 percent) located above Errol Dam. Table 1. lists storage locations and pertinent data for each storage site. Union Water Power Company operates and maintains the storage in the Rangeley lakes system, made up of 6 lakes and dams located in the upper basin above Errol Dam. The system of lakes is operated to maintain a flow of not less than 1,550 cfs (approximately 1 cubic foot per second per square mile) through releases at Errol dam as measured at Berlin, New Hampshire, per agreement with Union Water Power Company and 3 other power companies on the Androscoggin River, dating back to 31 March 1909. This flow is maintained primarily for downstream power uses and industrial developments along the Androscoggin River. During the summer and fall, releases from the lakes tend to empty the system, allowing the lakes to be fully drawn down for the spring run-off and subsequent refill season. The amount of storage in the Rangeley Lakes is equivalent to 12 inches of runoff from the 1,045 square miles of contributing drainage area above Errol Dam. This operation helps to greatly modify the effects of flood flows from the upper portion of the basin.

Currently there are 24 Federal Energy Regulatory Commission (FERC) licensed hydroelectric sites in the Androscoggin River Basin, 22 of which are located downstream of Errol Dam (Table 1a). Because of limited storage capacity, downstream power dams are run-of-river except the Gulf Island project, which has storage capacity primarily for daily or weekly "load fitting" operations.

TABLE 1

AVAILABLE STORAGE
ANDROSCOGGIN RIVER BASIN

Reservoir	Drainage Area (sq mi) Net	Drainage Area (sq mi) Gross	Draw Down (ft)	UseableStorage (million cu ft)	Capacity (acre-feet)
Upper Androscoggin Basin*					
Kennebago Lake	101	101	4	721	16,600
Rangeley Lake	99	99	4	1,340	30,800
Mooselookmeguntic Lake	182	382	12.2	8,360	191,900
Upper and Lower Richardson Lakes	90	472	17.5	5,690	130,600
Aziscohos Lake	214	214	45	9,510	218,300
Umbagog Lake	359	1,045	8	3,150	72,300
		Total Above			
Berlin, N.H.	28,771	660,500**			
Lower Androscoggin Basin					
Gulf Island Pond	2,862	10	1,100	25,300	
Little Androscoggin River					
Pennesseewasee Lake		23	5	192	
Thompson Lake	44	5	950		
Total Above					
Mechanic Falls, Maine	1,142	26,200			
Other Tributaries					
Lake Auburn	17	6	580	13,300	
Basin Total			31,593	725,300	

*Source - Union Water Power Company

**Equivalent to nearly 12 inches of runoff from 1,045 square miles of contributing drainage area above Errol Dam.

TABLE 1a

PERTINENT DATA - FERC LICENSED HYDROPOWER SITES

FERC LICENSE	PLANT NAME	OWNER	RIVER MILE	LOCATION	
2284 ME	Brunswick	Central Maine Power Co.	8.0	Brunswick	Maine
2284 ME	Topsham	Central Maine Power Co.	8.0	Topsham	Maine
4784 ME	Pejepscot	Pejepscot Paper Co.	12.7	Topsham	Maine
--	Lisbon Falls	Worumbo Div. J.P.Stevens Co.	16.0	Lisbon Falls	Maine
--	Norway	Central Maine Power Co.	--	Norway	Maine
2302 ME	Lewiston Falls	Union Water Power Co.	30.8	Lewiston	Maine
2302 ME	Lewiston	Pepperell Manufacturing Co.	30.8	Lewiston	Maine
2302 ME	Lewiston	W. S. Libby Co.	30.8	Lewiston	Maine
2302 ME	Lewiston	P. Hall Enterprises, Inc.	30.8	Lewiston	Maine
2302 ME	Lewiston	Bates Manufacturing Co.	30.8	Lewiston	Maine
2302 ME	Hill Div.	Bates Manufacturing Co.	30.8	Lewiston	Maine
2302 ME	Androscoggin	Bates Manufacturing Co.	30.8	Lewiston	Maine
2302 ME	Lewiston	Lewiston Public Works	30.8	Lewiston	Maine
2283 ME	Deer Rips	Central Maine Power Co.	33.6	Lewiston	Maine
2283 ME	Androscoggin No.3	Central Maine Power Co.	33.6	Lewiston	Maine
2283 ME	Gulf Island	Central Maine Power Co.	34.8	Lewiston	Maine
2375 ME	Livermore Mill	International Paper Co.	60.8	Livermore Falls	Maine
2375 ME	Otis	International Paper Co.	61.8	Chisholm	Maine
2375 ME	Jay	International Paper Co.	63.8	Jay	Maine
2375 ME	Riley	International Paper Co.	66.6	Jay	Maine
2333 ME	Rumford Lower	Rumford Falls Power Co.	87.2	Rumford	Maine
2333 ME	Rumford Upper	Rumford Falls Power Co.	87.4	Rumford	Maine
2300 NH	Shelburne	Brown Company	127.6	Shelburne	N. H.
2288 NH	Gorham	Public Service Co. of N.H.	130.3	Gorham	N. H.
2288 NH	Gorham	Brown Company	132.6	Gorham	N. H.
2327 NH	Cascade	Brown Company	135.6	Gorham	N. H.
2326 NH	Cross Power	Brown Company	136.1	Berlin	N. H.
2287 NH	J. Brodie Smith	Public Service Co. of N.H.	136.7	Berlin	N. H.
2423 NH	Riverside	Brown Company	137.8	Berlin	N. H.
2422 NH	Sawmill	Brown Company	138.2	Berlin	N. H.
2861 NH	Pontook	Union Water Power Co.	162.1	Dummer	N. H.
3133 NH	Errol	Union Water Power Co.	170.0	Errol	N. H.
--	Kennebago	Rangeley Power Co.	217.0	Kennebago	Maine

EXISTING CONDITIONS

PHYSICAL RESOURCES

Watershed Description

a. General. The Androscoggin River Basin is located principally in southwest Maine with a portion of its headwater area in northeastern New Hampshire. The basin's total drainage area is 3,450 square miles, with 720 square miles (about 20 percent) lying within New Hampshire. Numerous lakes and ponds cover over 143 square miles (approximately 4.1 percent) of the basin's area. The basin sub-divisions are shown on figure 1.

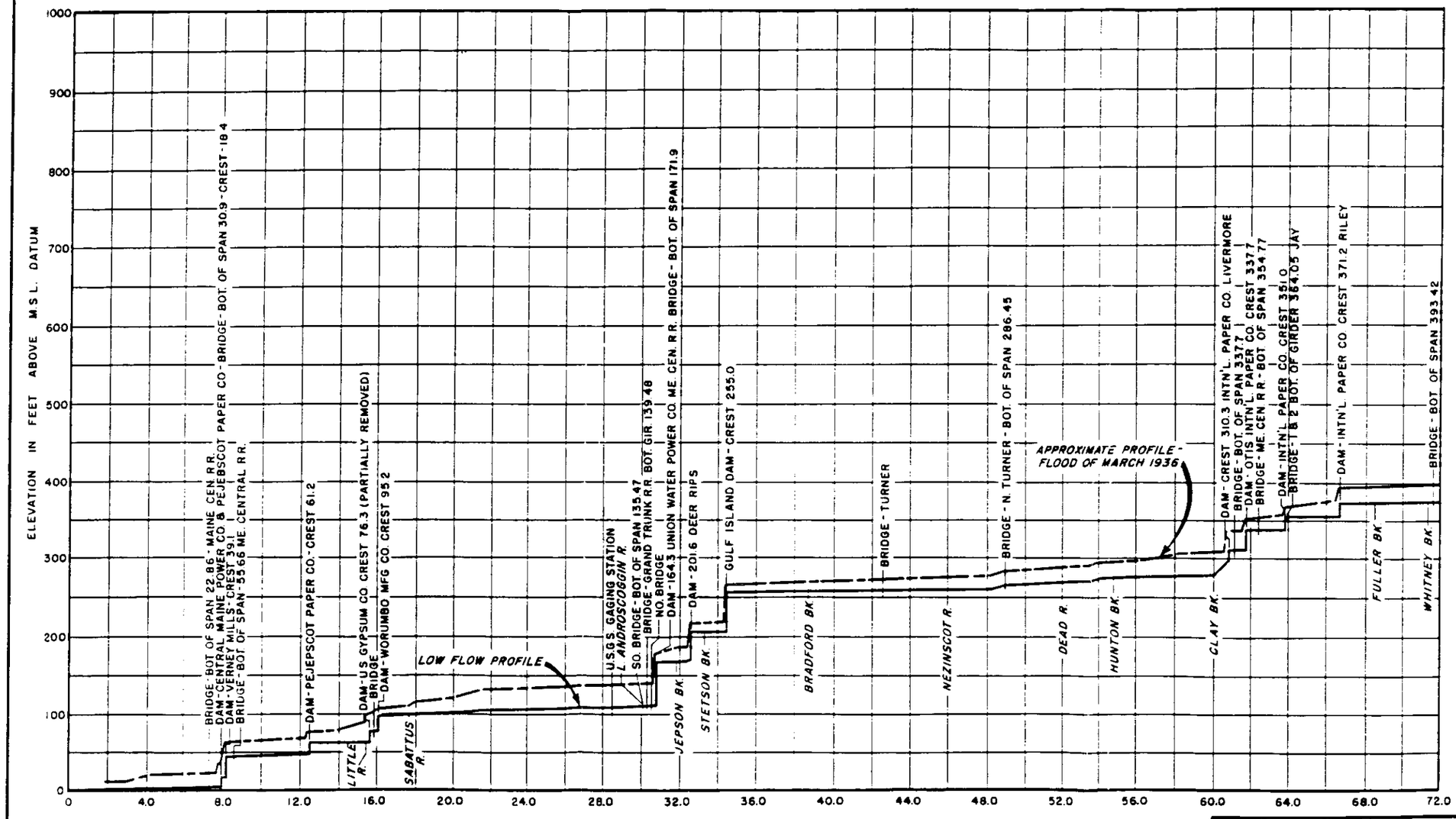
Hydrologically, the basin can be divided into three distinct areas, each representing about one-third of the water-shed. The first is the upper portion of the basin lying above Errol, New Hampshire with a drainage area of 1,045 square miles. There are 6 major lakes (collectively called the Rangeley Lakes) in this section of the basin, with a total useable storage capacity of 660,500 acre-feet. All are operated by the Union Water Power Company (UWPC) for power and recreation. These lakes, with their large usable storage capacity, have a modifying effect on floodflows, and as a result, this area historically has not been a major contributor to downstream flood peaks.

The second or middle section of the watershed lies between Errol, New Hampshire and the mouth of the Webb River, with a net drainage area of approximately 1,300 square miles. This area is characterized by mountainous terrain and relatively short tributaries with steep slopes. It is this section of the watershed which tends to contribute most to the flood peaks on the main stem of the Androscoggin River.

The lower third of the watershed drains a net area of 1,105 square miles and has drainage more typical of the Maine Coastal Region. This area, has long, flat tributaries, and many small lakes and ponds, which tend to retard and modify the tributaries' floodflows. Because of the long travel times along the main stem Androscoggin River and the hydrologic characteristics of these lower basin tributaries, historic floodflows from the lower basin have generally been synchronous with main stem peaks.

b. Androscoggin River. The Androscoggin River originates at Errol Dam, the outlet of Umbagog Lake in Errol, New Hampshire. The river flows in a southerly direction, turning east at Gorham, and south again at Livermore Falls to its outlet in Merrymeeting Bay. Between Umbagog Lake and tidewater at Brunswick, the Androscoggin River drops 1,245 feet in 161 miles, for an average slope of 7.7 feet per mile. Of this total fall, however, about 32 percent occurs at two locations. The first, a 240 foot drop in 2.5 miles near Berlin, New Hampshire, and the second a 180 foot drop in 1.6 miles near Rumford. Pertinent data for the Androscoggin River and its tributaries is shown in table 2. A profile of the main stem is presented in figures 3-5.

c. Headwater Tributaries. The headwaters, as defined in this report, is that area above Errol. The major headwater tributaries include the watersheds of the Cupsuptic, Kennebago, and Magalloway Rivers. The area extends north about 50 to 55 miles above the outlet of Umbagog Lake at Errol Dam, has a width of about 35 miles, and a drainage area of about 1,045 square miles.



ARMY N.E.D. BOSTON OCTOBER 7, 1952

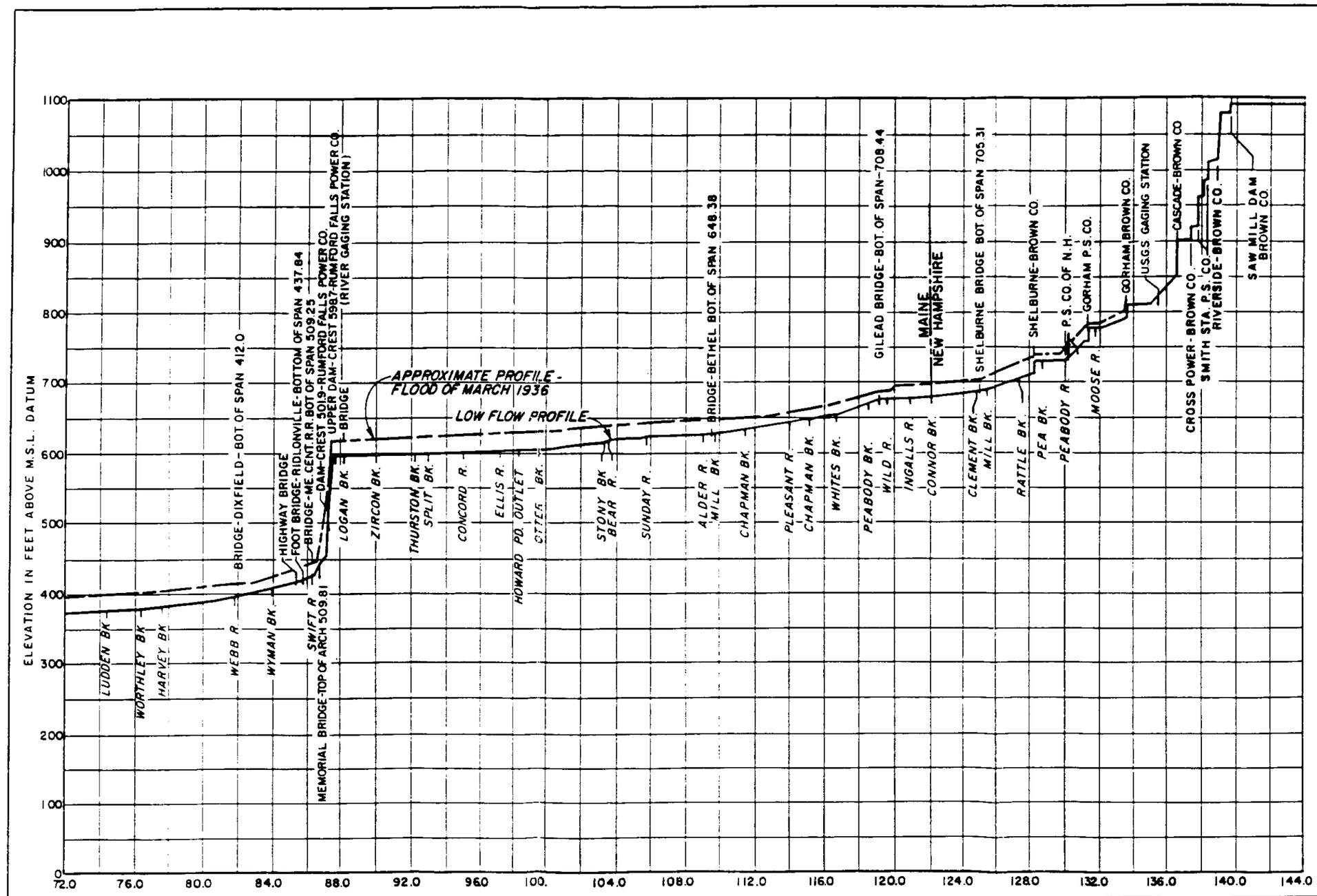
ANDROSCOGGIN RIVER FLOOD CONTROL

ANDROSCOGGIN RIVER PROFILE

ANDROSCOGGIN RIVER MAINE & N.H.

U.S. ARMY ENGINEER DIVISION
NEW ENGLAND
WALTHAM, MASS.

PLATE 3



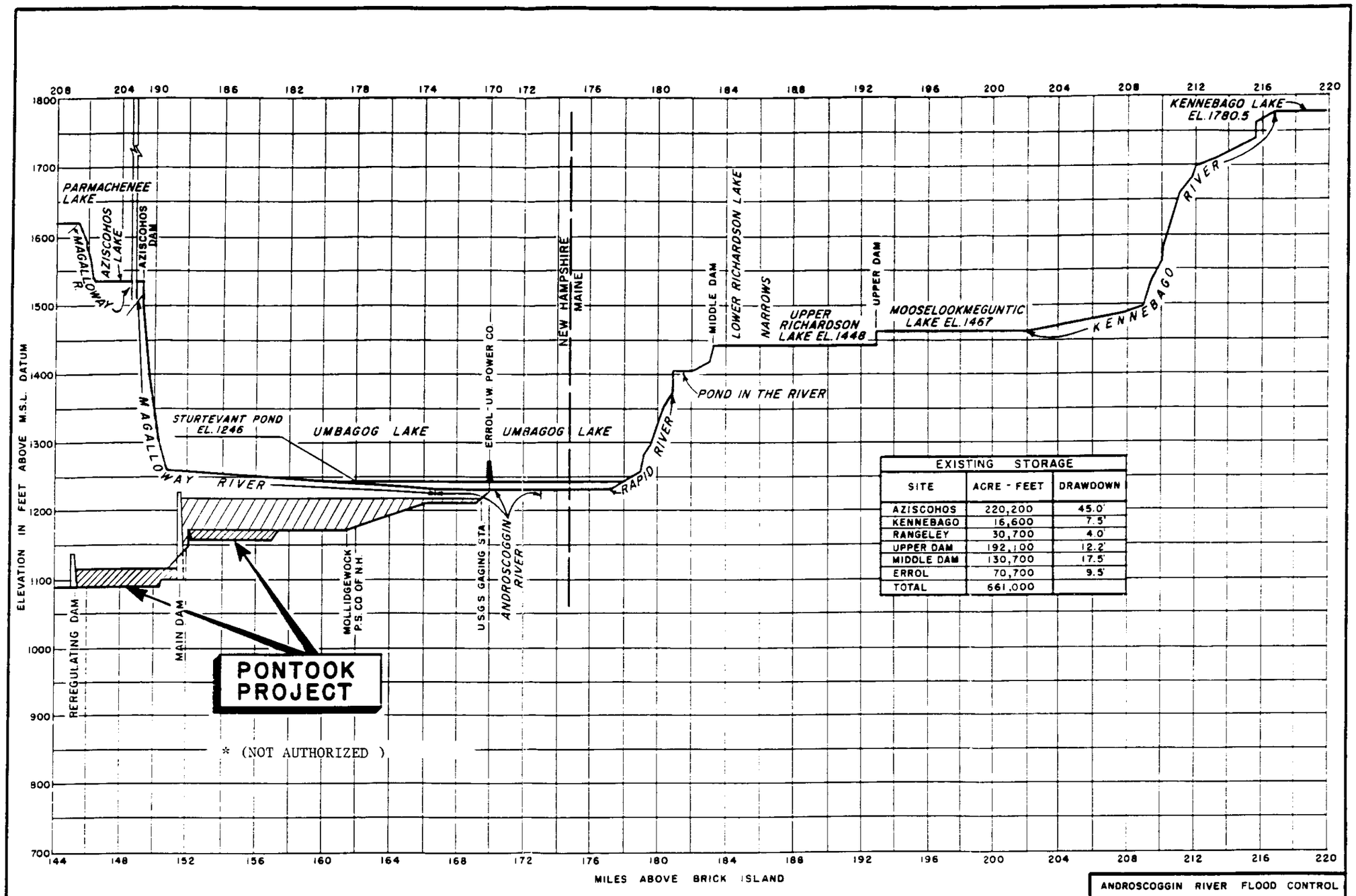
ANDROSCOGGIN RIVER FLOOD CONTROL

ANDROSCOGGIN RIVER PROFILE

ANDROSCOGGIN RIVER MAINE & N.H.

U.S. ARMY ENGINEER DIVISION
NEW ENGLAND
WALTHAM, MASS.

PLATE 4



EXISTING STORAGE		
SITE	ACRE - FEET	DRAWDOWN
AZISCOHOS	220,200	45.0'
KENNEBAGO	16,600	7.5'
RANGELEY	30,700	4.0'
UPPER DAM	192,100	12.2'
MIDDLE DAM	130,700	17.5'
ERROL	70,700	9.5'
TOTAL	661,000	

ANDROSCOGGIN RIVER FLOOD CONTROL

ANDROSCOGGIN RIVER PROFILE

ANDROSCOGGIN RIVER MAINE & N.H.

U.S. ARMY ENGINEER DIVISION
NEW ENGLAND
WALTHAM, MASS.

PLATE 5

TABLE 2

ANDROSCOGGIN RIVER AND TRIBUTARIES

River or Tributary	Drainage Area (sq mi)	Length (miles)	Fall (feet)
Cupsuptic River at Mouth	62.5	20	1,001
Kennebago River at Mouth	138	29	700
Magalloway River at Umbagog Lake	439	47	505
Diamond River at Mouth	154	17	85
Rapid River at Umbagog Lake	520	7	206
Androscoggin River at Errol, NH, USGS Gage	1,045	--	--
Androscoggin River near Gorham, NH, USGS Gage	1,363	--	--
Peabody River at Mouth	47	12	2,240
Moose River at Mouth	24	12	1,880
Wild River at Mouth	69	15	2,080
Sunday River at Mouth	51	14	1,620
Bear River at Mouth	43	13	860
Ellis River at Mouth	163	20	200
Androscoggin River at Rumford, ME, USGS Gage	2,067	--	--
Swift River at Mouth	125	25	1,795
Webb River at Mouth	132	15	285
Dead River at Mouth	89	23	650
Nezinscot River at Mouth	181	31	593
Little Androscoggin River at Mouth	353	46	580
Androscoggin River near Auburn, ME, USGS Gage	3,257	--	--
Androscoggin River at Head of Tidewater (Brunswick, ME)	3,450	161	1,245

(1) Cupsuptic and Kennebago Rivers. These two headwater tributaries originate in Cupsuptic and Rock Ponds, respectively. The Cupsuptic River, from its source at an elevation of 2,485 feet NGVD, flows south about 20 miles to Cupsuptic Lake. The Kennebago River also follows a general southerly course from its headwater pond, at an elevation of 2,167 feet NGVD, to its mouth at

Mooselookmeguntic Lake, a distance of about 29 miles. Cupsuptic Lake is the northern portion of the large Mooselookmeguntic Lake which has a normal water surface elevation of about 1,467 feet NGVD. The flow from this lake system discharges directly to the Upperand Lower Richardson Lakes, which has a normal water surface elevation of 1,448 feet NGVD. Discharges from Middle Dam at the Lower Richardson Lake form the Rapid River, which flows about 6 miles to Umbagog Lake. Normal pool elevation at Umbagog Lake is 1,245 feet NGVD.

(2) Magalloway River. The Magalloway River has its source in the mountains along the Maine/New Hampshire border and flows through Aziscohos Lake and then follows a meandering course in a southerly direction for about 47 miles to its mouth at Umbagog Lake. It drains an area of 439 square miles and has a fall of approximately 500 feet. The principal tributary of the Magalloway River is the Diamond River consisting of the Dead Diamond and Swift Diamond Rivers. The Diamond Rivers drain steep mountainous slopes with headwater elevations in excess of 3,000 feet NGVD. From the confluence of the two Diamond River tributaries, the river then flows in a southeasterly direction for about 1.7 miles, with a slope of approximately 5 feet per mile, to its junction with the Magalloway River, about 10.5 miles above its mouth at Umbagog Lake.

(3) Rapid River. Rapid River has its source at the outlet of the Richardson Lakes at Middle Dam and flows on ageneral northwesterly course for about 7 miles to Umbagog Lake. It drains an area of about 520 square miles which includes the Kennebago, Rangeley, Mooselookmeguntic and Richardson Lakes.

d. Downstream Tributaries. The principal tributaries of the mainstem Androscoggin River below Umbagog Lake are listed below in downstream order:

(l) Moose River. The Moose River has its source in the town of Bowman, New Hampshire and flows in a general northeast direction to its confluence with the Androscoggin River in the town of Gorham, New Hampshire. It has a drainage area of about 24 square miles and extends from the peaks of the Presidential Range for about 12 miles to its mouth with a total fall of about 1,880 feet. The topography of the basin is mountainous with steep slopes producing rapid runoff.

(2) Peabody River. The Peabody River rises in the northwest portion of the town of Pinkham Notch, New Hampshire and flows in a general northwesterly direction to its confluence with the Androscoggin River in the southeast corner of the town of Gorham, New Hampshire. It drains an area of about 47 square miles and extends from the summit of Mount Washington for about 12 miles to its mouth and has a total fall of about 2,240 feet. The topography of this basin is similar to that of Moose River basin.

(3) Wild River. The Wild River has its source at North Ketchum Pond in Beans Purchase, New Hampshire. The river follows a generally northeasterly course entering the Androscoggin River in the northwest corner of Gilead, Maine. Like the Moose and Peabody Rivers, it drains the eastern slopes of the White Mountains. Its drainage area of 69 square miles extends from the summit of Wildcat Mountain, adjacent to Mount Washington, for about 15 miles and has a total fall of about 2,080 feet. The topography at this basin is mountainous and similar to the Moose and Peabody River basins.

(4) Sunday River. The Sunday River has its source in the vicinity of Goose Eye mountain, draining an area north of the Androscoggin River in Riley, Maine. It flows in a general

southeasterly direction for about 14 miles to its confluence with the Androscoggin River in the town of North Bethel, Maine. It drains an area of approximately 51 square miles and has a fall of about 1,620 feet.

(5) Bear River. The Bear River has its source just south of the town of Grafton Notch, Maine and flows in a southeasterly course for about 13 miles entering the Androscoggin River at Newry, Maine. Its drainage area is about 43 square miles and its fall is about 860 feet.

(6) Ellis River. The Ellis River rises in Ellis Pond in the town of Roxbury, Maine and flows generally south about 20 miles to its confluence with the Androscoggin River near Hanover, Maine. The topography of the basin above Andover, Maine is mountainous with steep slopes and very little effective channel storage. Below this point, there is a broad flat plain which extends about seven miles to below North Rumford. The Ellis River has a drainage area of 163 square miles and a fall of about 200 feet. Unlike the previously mentioned tributaries draining steep mountainous slopes, the Ellis River is more hydrologically sluggish with a considerable amount of natural storage.

(7) Swift River. Swift River rises in Swift River Pond about 6 miles northeast of the town of Houghton, Maine and flows southerly about 25 miles to its confluence with the Androscoggin River at Mexico and Rumford. It drains an area of 125 square miles and has a fall of approximately 1,800 feet.

(8) Webb River. The Webb River rises in Lake Webb in the town of Weld, Maine at an elevation of 678 feet NGVD. The river follows a meandering course in a southerly direction for about 15 miles to its mouth at the Androscoggin River at Dixfield, Maine. Its drainage area is 132 square miles and its fall about 285 feet.

(9) Dead River. The source of this tributary is in Kimball Pond on the town line between Vienna and New Sharon,Maine. The flow from the pond is first confined to a small stream that runs south about 3.5 miles at an average slope of 160 feet per mile. It then continues south about 17.5 miles through a series of 9 lakes and ponds connected by short streams, dropping approximately 75 feet within this reach of lakes. The Dead River originates at the outlet of Androscoggin Lake, the most southerly lake in the series, and flows in a general northwesterly direction for about 7 miles, at a very gentle slope, to its confluence with the Androscoggin River 5 miles north of West Leeds. It drains an area of 89 square miles and is classified as hydrologically sluggish with extensive storage within the watershed, more typical of the Maine Coastal Region.

(10) Nezinscot River. The East and West Branches of the Nezinscot River rise in the southern slopes of a hilly region in the southern part of Peru and the northwest corner of Woodstock, Maine. The two branches flow in a general southeasterly direction about 16 miles, uniting at a point one mile below the village center of Buckfield to form the Nezinscot River. Below Buckfield, the Nezinscot River follows an easterly course for 14 miles to its mouth at the Androscoggin River at Keens Mills, about 4.5 miles northeast of Turner, Maine. It has a drainage area of 181 square miles and a fall of about 590 feet from the confluence of the two branches to the Androscoggin.

(11) Little Androscoggin River. The Little Androscoggin River rises in Bryant Pond in Woodstock, Maine at an elevation of about 700 feet above mean sea level. The river flows south

for a short distance and then generally east for the remainder of its 46 mile length where it joins the Androscoggin River at Auburn, Maine. It drains an area of 353 square miles and has a fall of 580 feet.

Topography and Geology

The Upper Androscoggin Basin lies mostly within the White Mountain Section of the New England Physiographic Province. The mountainous terrain is broken by several relatively wide stream valleys and, locally, there are large basins occupied by great lakes such as the Rangeleys and others that are connected to discharge to the Androscoggin.

Prior to glaciation, the topography was in a mature stage of erosion with a network of sharply incised stream valleys having graded profiles. Lakes and swamps did not exist and the overburden was the product of weathering of the bedrock. Glaciation modified this topography by erosion and deposition and disrupted the drainage system. There are evidences that the present circuitous, south and easterly course of the Androscoggin River is altered from a pre-glacial drainage westward to the Connecticut River Valley.

Glacial till, a mass mixture of soil and rock debris of all sizes scraped up and transported by the ice, variably blankets the bedrock surface throughout most of the Upper Basin. The till is thin or absent at high elevations and of considerable thicknesses on lower hill slopes and in the valley sections. Overlying the till in the valleys and in local basins are sorted deposits of glacial materials that were outwashed from the ice by meltwaters and deposited as sand and gravel terraces and plains.

The bedrocks of the basin, except for an area of relatively young slates and volcanics near the Rangeley Lakes, are very old sediments that have been metamorphosed to schist, gneiss and quartzite. These rocks have been much folded to a general northeasterly trend of structure and are frequently cut by igneous intrusions of a mainly granitic composition.

The pegmatites (coarse-grained granites) of the basin are a source of marketable minerals, principally feldspar, mica, and beryl with subordinate occurrences of rare minerals and minerals of gem quality. Principal production has been from the Rumford-Newry area at several intermittently operated mines and quarries, none of which are affected by reservoir plans. The glacial sands and gravel deposits, occurring as terraces and plains in the major valleys, are the only resources of a mineral nature that would be affected by reservoir construction.

Climatology

The Androscoggin River Basin is characterized by cool summers and cold snowy winters. Prevailing westerlies and cyclonic disturbances from the west and southwest bring frequent but short periods of heavy precipitation to the basin. Most of the basin lies inland and escapes the brunt of coastal hurricanes and accompanying intense rainfall. The basin's average annual temperature is 43°F. The range of mean monthly temperatures is wide, with 64 to 70°F in Jul yand August to 15 to 20°F in January and February. Temperature extremes range from occasional highs over 100°F to lows less than -30°F. Table 3 lists monthly and annual temperatures at Errol and Berlin, New Hampshire and Rumford and Lewiston, Maine. Average annual precipitation is 40 inches, uniformly distributed throughout the year. Average monthly and annual precipitation over the

basin is listed in table 4. Most of the winter precipitation is in the form of snow. Annual snowfall varies from 80 inches near the coast to 170 inches in the headwaters of the basin. Water content of the snow cover in early spring is about 6 to 8 inches; 10 inchesis common in the higher basin elevations. Table 5 lists mean monthly and annual snowfall at 4 locations in the basin.

TABLE 3

MONTHLY TEMPERATURES
(Degrees, Fahrenheit)

Lewiston, Maine
Elevation 182 Ft NGVD
100 Years of Record

Month	Mean	Max	Min
January	19.5	64	-28
February	20.6	62	-28
March	30.8	82	-18
April	42.5	87	10
May	54.4	101	27
June	64.1	99	34
July	69.8	102	44
August	67.8	98	38
September	59.9	97	28
October	49.3	90	18
November	36.9	74	2
December	24.3	65	-27
ANNUAL	44.9	102	-28

Rumford, Maine
Elevation 674 Ft NGVD
82 Years of Record

Month	Mean	Max	Min
January	17.2	64	-34
February	18.6	58	-34
March	29.1	79	-23
April	41.1	89	- 1
May	53.2	97	24
June	61.8	98	26
July	67.9	101	38
August	65.5	100	36
September	57.6	95	22
October	47.0	88	15
November	34.7	76	-5
December	21.8	63	-29
ANNUAL	42.9	101	-34

Berlin, New Hampshire
Elevation, 1,110 Ft NGVD
72 Years of Record

Month	Mean	Max	Min
January	14.7	67	-41
February	14.6	63	-39
March	30.6	80	-29
April	45.7	88	- 9
May	53.2	94	3
June	63.0	98	24
July	68.0	100	34
August	62.9	97	20
September	56.5	94	8
October	4.0	88	8
November	33.7	77	-13
December	26.1	66	-44
ANNUAL	42.8	100	-44

Errol, New Hampshire
Elevation 1,280 Ft NGVD
9 Years 1932 thru 1941

Month	Mean	Max	Min
January	16.9	53	-30
February	18.6	49	-24
March	27.2	64	-20
April	40.1	78	5
May	51.9	88	26
June	61.7	92	32
July	66.4	92	44
August	64.0	90	36
September	56.0	87	24
October	44.9	78	18
November	34.3	68	- 6
December	21.6	60	-32
ANNUAL	42.0	92	-32

TABLE 4

MONTHLY PRECIPITATION RECORDS

Month	Lewiston, Maine Elevation 182 Ft NGVD 110 Years of Record Mean (In Inches)	Rumford, Maine Elevation 674 Ft NGVD 91 Years of Record Mean (In Inches)	Errol, New Hampshire Elevation 1,280 Ft NGVD 100 Years of Record Mean (In Inches)	Berlin, New Hampshire Elevation 1,110 Ft NGVD 90 Years of Record Mean (In Inches)
January	3.86	2.95	2.70	2.73
February	3.63	2.59	2.53	2.30
March	4.17	3.38	2.89	2.81
April	3.66	3.35	2.92	2.90
May	3.38	3.42	3.28	3.16
June	3.41	3.59	3.72	3.87
July	3.49	3.74	3.37	3.48
August	3.32	3.42	3.70	3.33
September	3.46	3.51	3.00	3.37
October	3.63	3.50	3.09	3.24
November	4.26	3.93	3.61	3.62
December	4.16	3.36	3.23	3.04
ANNUAL	44.24	40.90	38.15	37.77

TABLE 5

MEAN MONTHLY SNOWFALL
(Depth in Inches)

Lewiston, Maine
Elevation 182 Ft NGVD
96 Years of Record

Month	Snowfall
January	
February	20.8
March	13.3
April	5.0
May	0.1
October	0.3
November	5.8
December	15.7
ANNUAL	82.1

Rumford,jMaine
Elevation 674 Ft NGVD
82 Years of Record

MONTH	Snowfall	
21.0	January	22.0
February	20.6	
March	15.9	
April	6.6	
May	0.4	
October	0.6	
November	7.5	
December	18.4	
ANNUAL	91.9	

Berlin, New Hampshire
Elevation 1,110 Ft NGVD
61 Years of Record

Month	Snowfall
January	22.6
February	21.9
March	20.6
April	7.0
May	0.4
October	1.2
November	9.9
December	18.0
ANNUAL	101.6

Errol, New Hampshire
Elevation 1,288 Ft NGVD
39 Years of Record

Month	Snowfall
January	23.5
February	17.9
March	16.4
April	4.2
May	0.7
October	0.3
November	3.1
December	20.9
ANNUAL	92.9

HYDROLOGIC CHARACTERISTICS

Streamflow

a. Runoff. Average annual streamflow is approximately 1.8 cfs per square mile of watershed area. This is equivalent to 25 inches of runoff, or about 60% of the average annual precipitation. Over 40 percent of the runoff occurs during March, April, and May, with the rest uniformly distributed throughout the year.

b. Streamflow Records. The U.S. Geological Survey (USGS) has operated a system of streamflow gaging stations at various sites and for various periods of time in the basin since the early 1900's. Nine stations are presently in operation. Early records were also maintained by local dam operators for the power companies; the Rumford gage was maintained by the Rumford Falls Power Company from 1892 to 1979. Table 6 lists the gages used in the analysis of the basin floods. It is noted that some of the gaging stations have been discontinued, and many of the tributaries have never been gaged. Supplemental flow and reservoir storage data for recent floods was furnished by the Union Water Power Company.

Floods of Record

a. Flood History. The history of floods in the Androscoggin River basin goes back over 200 years with records indicating floods in 1785, 1814, 1820,1826, 1827, 1846, and 1869. However, information on the relative magnitude of flood events is generally not available prior to 1892, when the Rumford Falls Power Company began recording river flows at Upper Falls, Rumford, Maine. High flows in the basin occur almost annually, usually in the spring months of March, April, or May, and vary in magnitude depending on the water content of the melting snow cover, the occurrence of coincidental heavy spring rainfall, the temperature and the extent of frost. The three greatest known floods; March 1936, March/April 1987, and March 1953, were a result of a combination of these factors. Discharges and stages of spring floods can be increased due to the formation of ice jams. This occurred during the March 1936 flood at Auburn. Heavy rainfall at other times of the year can also produce flooding as evidenced by the floods of November 1927 and 1950, and June 1942 and 1947.

b. Recent Floods. The March 1936 flood was the greatest flood of record in the lower reaches of the Androscoggin River basin. This flood was caused by unseasonably warm temperatures and heavy rain on top of a snow cover having approximately 10 inches of water equivalent. Flooding at several locations was further aggravated by severe ice jams. Two distinct storms occurred in March. During the first storm, 11 to 13 March, 5.8 inches of rainfall was recorded in Rumford, Maine and 7.8 inches at Pinkham Notch, New Hampshire. During the second storm, 16 to 21 March, 5.8 inches was recorded at Rumford and 13.0 inches at Pinkham Notch. The second storm produced the highest recorded peak flow at Rumford (74,000 cfs) and the largest flood losses ever experienced

TABLE 6

STREAMFLOW RECORDS - ANDROSCOGGIN RIVER BASIN

Location of Gaging Station	Drainage Area (sq mi)	Period of Record	Discharge (cfs) Mean	Maximum	Minimum
Diamond River nr Wentworth Location, N.H.	153	1941-	349	8,630 06/16/43	6.8
Androscoggin River Leakage at Errol, N.H.	1,045	1905-	1,905	16,500 05/22/69	
Androscoggin River at Berlin, N.H.	1,350	1913-1928	2,313	20,000 06/18/17	960*
Androscoggin River at Gorham, N.H.	1,363	1928-	2,467	20,000* 04/30/23	456
Wild River at Gilead, ME	69.5	1964-	183	19,000 04/05/84	7.6
Ellis River at South Andover, ME	131	1963-1982	250	5,630 12/29/69	12
Androscoggin River at Rumford, ME	2,067	1892-	3,724	74,000 03/20/36	625*
Swift River nr Roxbury, ME	95.8	1929-	199	16,800 10/24/59	3.8
Nezinscot River at Turner Center, ME	171	1941-	306	13,900 03/27/53	5.6
Little Androscoggin River at South Paris, ME	76.2 1931-	1913-1924	139	9,300 04/11/87	1
Little Androscoggin River at Auburn, ME	328 1982	1940-	569	16,500 03/28/53	14*
Androscoggin River at Auburn, ME	3,257	1928-	1651	135,000	340*

TABLE 6a

MAJOR FLOOD FLOWS - ANDROSCOGGIN RIVER BASIN

LOCATION OF USGS GAGING STATION	DRAINAGE AREA (SQ. MI.)	PERIOD OF RECORD FROM	PEAK DISCHARGES (CFS) MARCH 1936	MARCH 1953	MARCH-APRIL 1987
Androscoggin River at Gorham, N.H.	1363	1928	19,900	17,900	16,020
Androscoggin River at Rumford, ME	2067	1892	74,000	56,700	57,000
Androscoggin River at Auburn, ME	3257	1928	135,000*	95,800	102,000
Swift River near Roxbury, ME	96	1929	10,500	10,200	15,860
Nezinscot River at Turner Center, ME	171	1941	--	13,900	9,990

*Affects of Ice Jam, Estimated Peak 118,000 CFS

in the basin. The March/April 1987 flood, the second largest basin-wide storm, was caused by a pair of rainstorms, augmented by snowmelt in the higher elevations of the basin. The first storm, occurring from 31 March to 1 April, was a fast moving storm system with heavy rainfall, strong southerly winds, and temperatures in the 50's and 60's. Two to four inches of rain fell over the Androscoggin on "ripe" snowpacks with 3 to 5 inches of water equivalent. Major flooding was experienced along the entire length of the main river, from Berlin to Brunswick, and along several tributaries. The recorded peak flow at Rumford was 57,000 cfs. The second storm, 4 to 8 April, was an intense, slow moving storm, delivering most of its punch to the southern and central parts of New England. About 1 to 2 inches of rain fell over the Androscoggin.

The March 1953 flood was the third largest basin-wide flood. Precipitation occurred during most of the month, culminating with approximately 5 inches falling over the basin from 24-27 March. Rainfall amounting to over 9 inches was recorded at Pinkham Notch in the White Mountain Region. Flooding throughout the watershed was comparable to the recent April 1987 event. The recorded peak flow at Rumford was 56,700 cfs. Table 6a lists the three largest basin wide floods of record at USGS gaged locations within the basin.

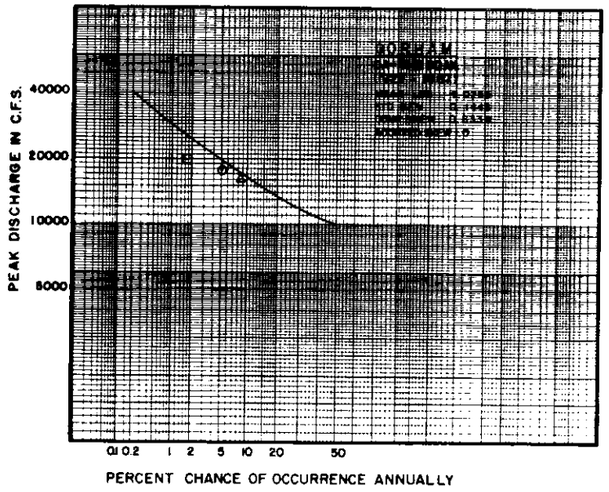
Discharge Frequencies

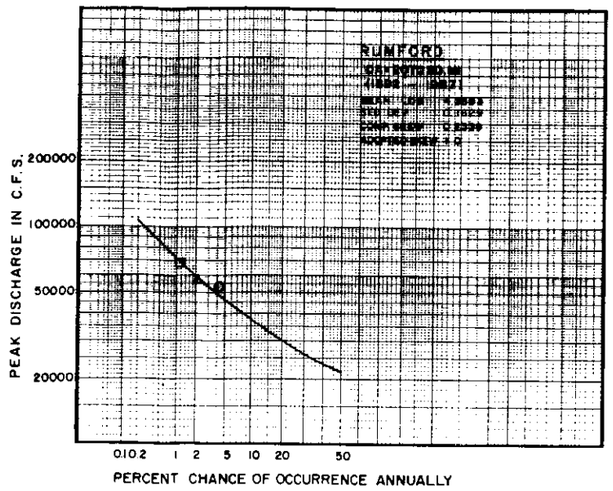
a. General. Peak discharge frequencies were developed at pertinent USGS gaging stations within the watershed. In general, statistical analysis of the recorded peak annual flows (including March/April 1987, where available) were performed using a Log Pearson Type III distribution in accordance with guidelines as presented in WRC Bulletin 17B.

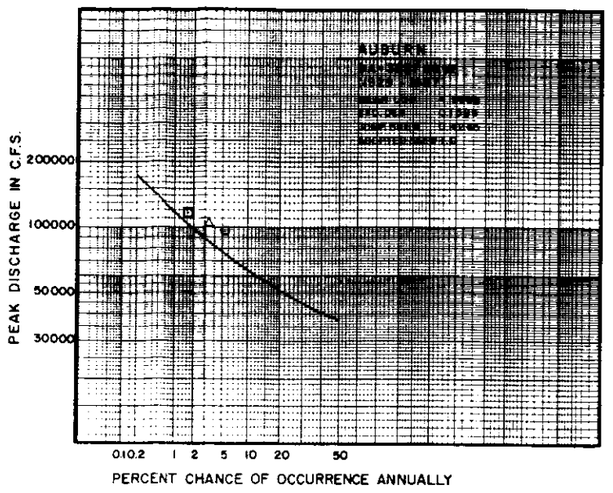
b. Androscoggin River. Peak discharge frequencies were computed for the gages at Gorham, Rumford, and Auburn. The gaged data at Errol was not analyzed due to the high degree of regulation upstream of Errol. The computed main stem curves, with the resulting statistics shown on the individual curves, are shown on plate 6. Based on previous Corps of Engineer studies, a regional skew coefficient of 1.0 was adopted.

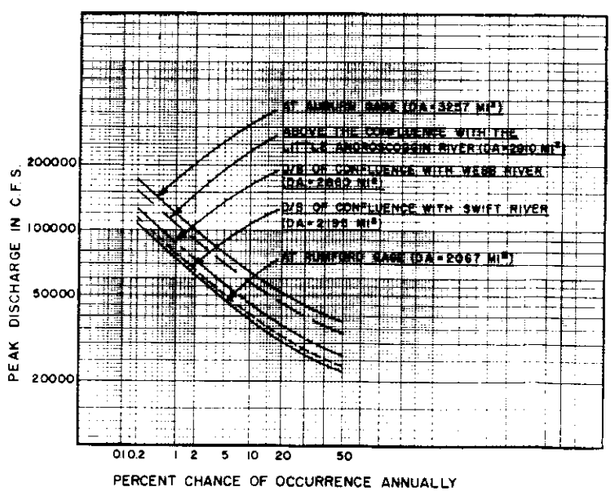
Since the major damage centers within the basin are located downstream of Rumford, several steps were taken to develop discharge frequencies at pertinent locations between the Rumford and Auburn gages. The first, just below the confluence with the Swift River (DA = 2,195 square miles), was computed by transferring the adopted Rumford curve by straight drainage area ratio. This ratio was considered reasonable based on the ratio of historic flood peaks (1936, 1953, and 1987) at the two locations. Further downstream, below the confluence with the Webb River (DA = 2,660 square miles), a second curve was calculated by transferring the adopted Rumford curve by drainage area ratio to the 0.7 exponential power, again in general agreement with observed and calculated historic flood peaks at the two locations. The computed curve at Auburn was used to develop a discharge frequency curve at one upstream location, above the confluence with the Little Androscoggin River (DA = 2,910 square miles). After reviewing historic flood peaks, a straight drainage area ratio was considered reasonable and adopted to transfer computed discharges.

c. Tributaries. Peak discharge frequencies were also developed for the following gaged tributaries within the Androscoggin Basin: the Wild River, Ellis River, Swift River, Nezinscot River, and Little Androscoggin River. The computed curves, along with the resulting statistics for each curve, are shown on plate 7.









LEGEND

□ 1936

△ 1987

○ 1953

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

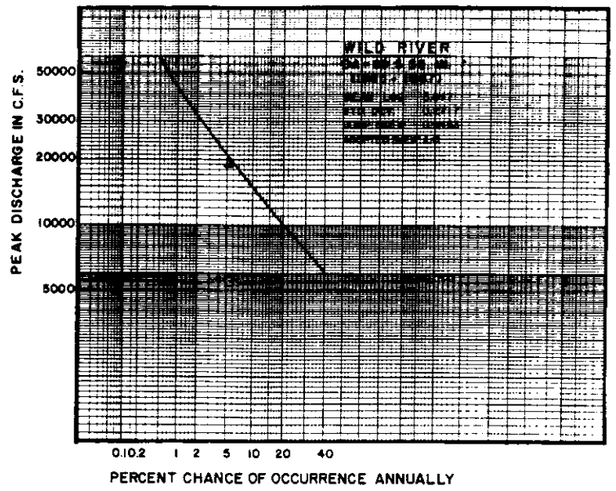
PEAK DISCHARGE FREQUENCIES

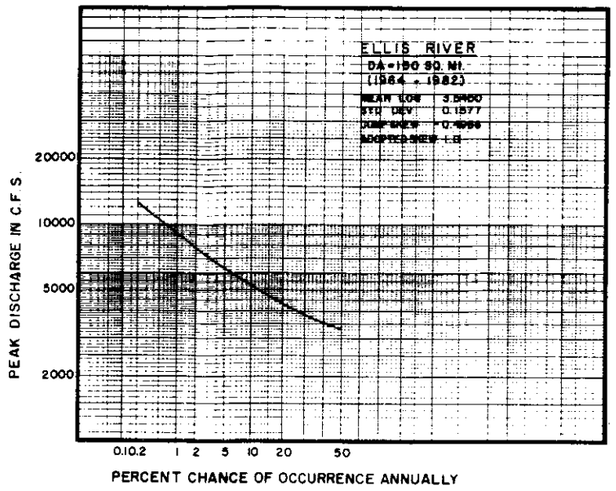
MAIN STEM

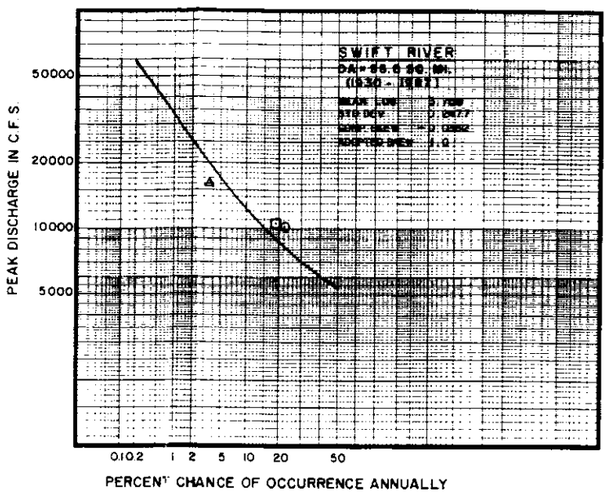
ANDROSCOGGIN RIVER

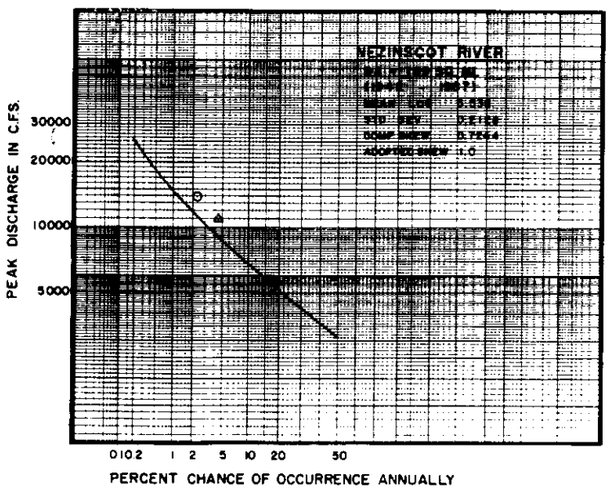
HES FEB. 1989

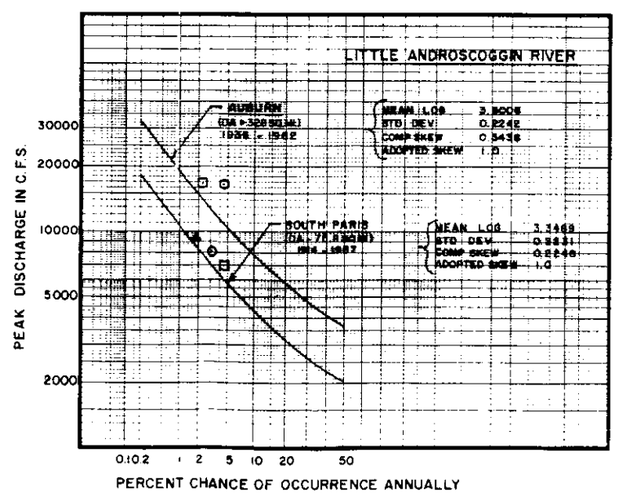
PLATE 6











LEGEND

□ 1936

△ 1987

⊙ 1953

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS

PEAK DISCHARGE FREQUENCIES

TRIBUTARY WATERSHEDS

HES FEB. 1989

PLATE 7

On the Little Androscoggin River damage areas were located downstream of the Auburn gage. Therefore, discharge frequencies were developed at these locations by transferring the computed curve at the gage by drainage area ratio to the 0.7 exponential power.

Stage Frequencies

As part of the New England New York Inter-Agency Committee (NENYIAC) studies and a Survey Report for the river basin (reference a and b), the Corps of Engineers conducted extensive damage surveys throughout the watershed. As a result of these investigations, areas having the highest damage potential were found to be along the Androscoggin River, generally south of Rumford and along the Little Androscoggin River from the Auburn gage site to the mouth. Hydraulic analysis during these past studies developed discharge rating curves at many hydraulic structures along both rivers. The rivers were then separated into damage zones with one or more of these rating curves representing conditions within the reach. These rating curves represent free flow conditions and are not applicable at times of ice blockage or excessive debris buildup, both of which could affect local river stages. Also, these Corps. developed rating curves were compared with flood profiles presented in the more recently prepared FEMA flood insurance studies at various communities within the basin. There is relatively close agreement between the rating curves and computed flood profiles in the flood insurance study reports. Therefore, the previously developed rating curves were utilized, along with adopted discharge-frequency curves, to develop stage-frequency data for both the Androscoggin and Little Androscoggin Rivers. This data is presented in table 7. Also shown in table 7 are (USGS) 1936 and 1987 high water mark information, where available. In addition, pertinent stage frequency curves are shown on plates 9a-c.

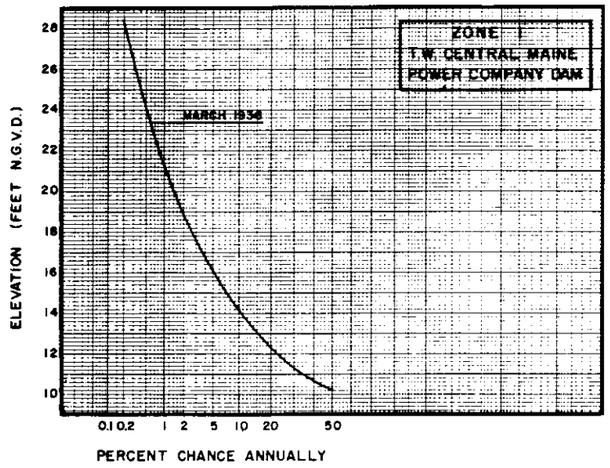
As can be seen from the various hydraulic analysis and surveyed high water mark information, river stages during major flood events are between 15 and 25 feet above normal along the Androscoggin between Rumford and Auburn.

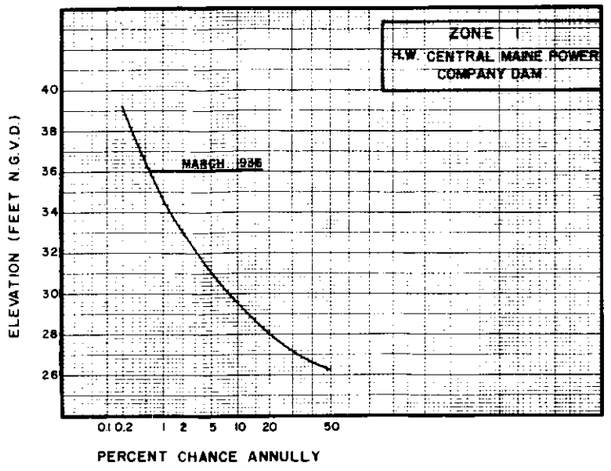
TABLE 7

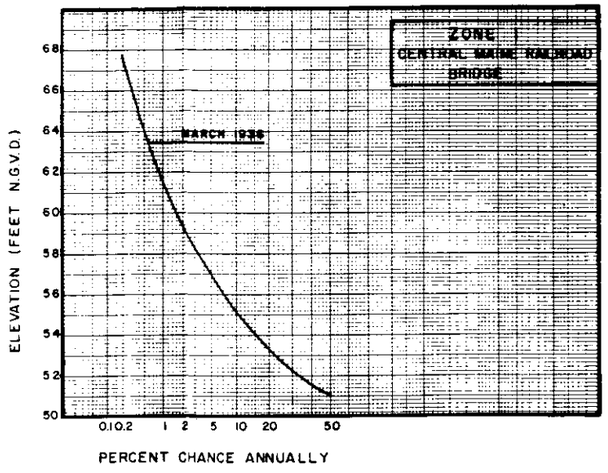
ELEVATION-FREQUENCY DATA

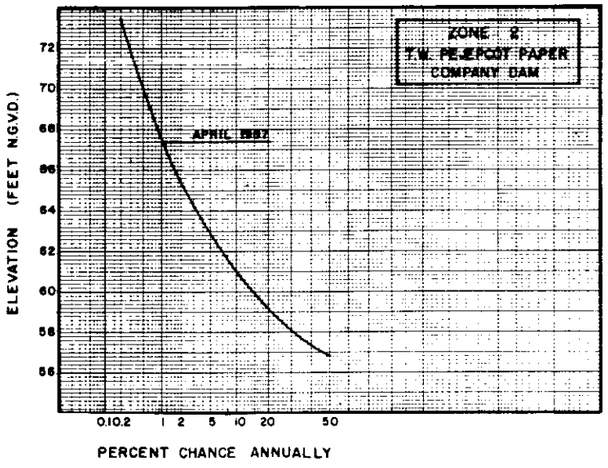
ANDROSCOGGIN RIVER

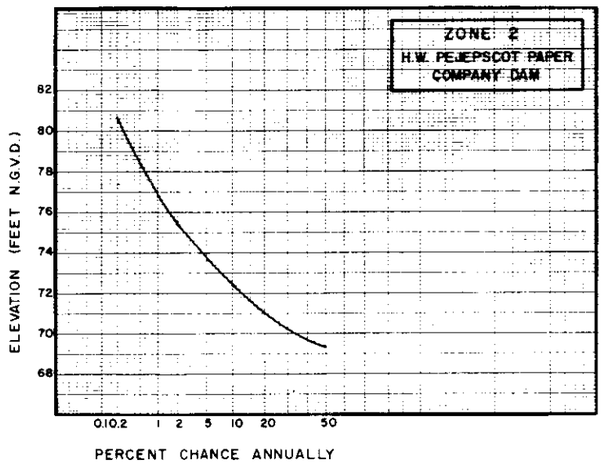
River Mile	Zone	Location	Elevations (Feet NGVD)						
			2-Year	10-Year	50-Year	100-Year	500-Year	1936	1987
7.9	(1) Mouth to Pejepscot Paper Co. Dam, RM 12.5	T.W. Central Maine Power Co. Dam	10.3	14.2	18.8	21.4	28.5	23.4	-
8.0	(1) As above	H.W. Central Maine Power Co. Dam	26.2	29.6	33.1	34.8	39.3	36.1	-
8.6	(1) As above	Central Maine Railroad bridge	51.1	55.1	59.4	61.7	67.8	63.5	-
13.6	(2) Pejepscot Paper Co. Dam, RM 12.5, to mouth Sabattus River, RM 17.7	T.W. Pejepscot Paper Co. Dam	56.8	61.1	65.3	67.6	73.5	75.7*	67.4
13.7	(2) As above	H.W. Pejepscot Paper Co. Dam	69.3	72.5	75.5	76.9	80.7	79.1*	79.2*
15.8	(2) As above	D/S U.S. Gypsum Co. Dam	75.6	79.6	83.2	85.1	90.2	86.6	-
16.1	(2) As above	H.W. Worumbo Manufacturing Co. Dam	100.8	102.8	105.0	106.2	109.6	107.2	104.1
28.4	(3) Mouth, Sabattus River, RM 17.7 to mouth, Little Androscoggin River, RM 30.1	USGS gage at Auburn	120.9	126.9	132.4	135.0	141.0	136.8	132.8
30.6	(4) Mouth, Little Androscoggin River, RM 30.1 to Union Water Power Co. Dam, Auburn, RM 30.8	Route 202 Highway bridge	130.2	135.1	140.3	143.1	150.0	144.9	140.5
30.8	(5) Union Water Power Co. Dam RM 30.8 to mouth, Nezinscot River, RM 44.9	Union Water Power Co. Dam	169.7	172.0	175.0	176.6	181.0	177.6	174.2
33.6	(5) As above	Deer Rips Dam	207.4	209.7	212.0	213.3	216.5	210.3	-
34.8	(5) As above	Gulf Island Dam	-	262.0	263.0	264.7	267.8	265.6	264.2
59.8	(6) Mouth, Nezinscot River, RM 44.9 to International Paper Co. Dam, Livermore Falls, RM 60.9	River Reach at 59.8	288.5	294.4	300.4	303.5	311.9	305.0	302.8

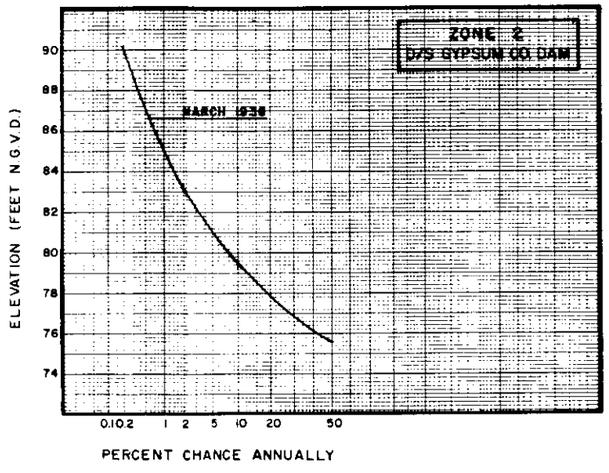


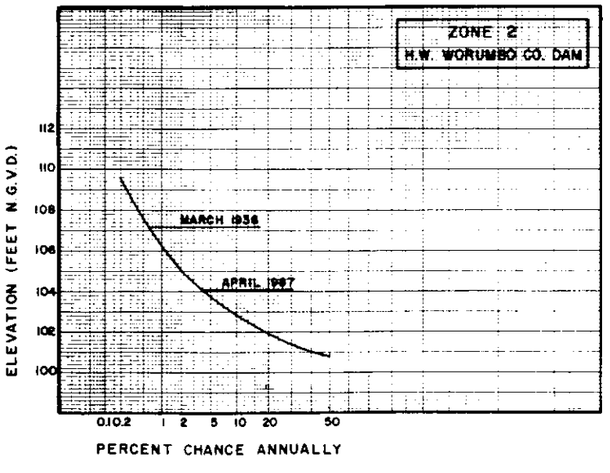


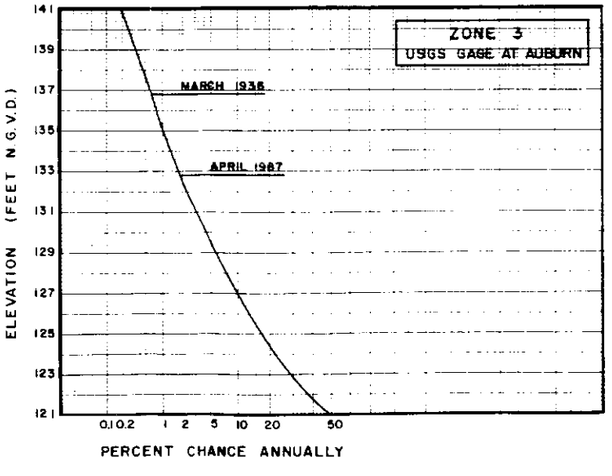












NOTE:

MARCH 1936 FLOOD LEVELS AFFECTED BY ICE JAMS.

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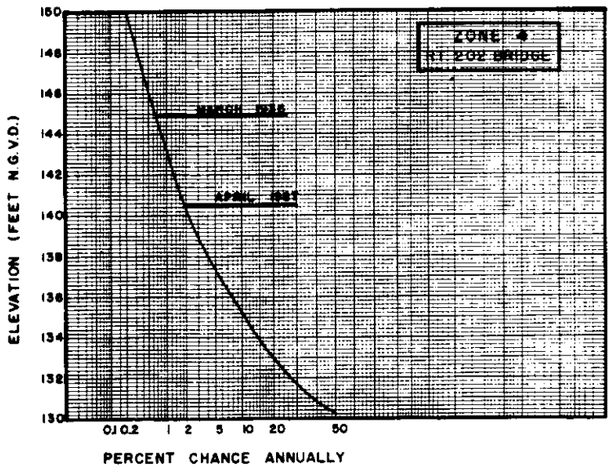
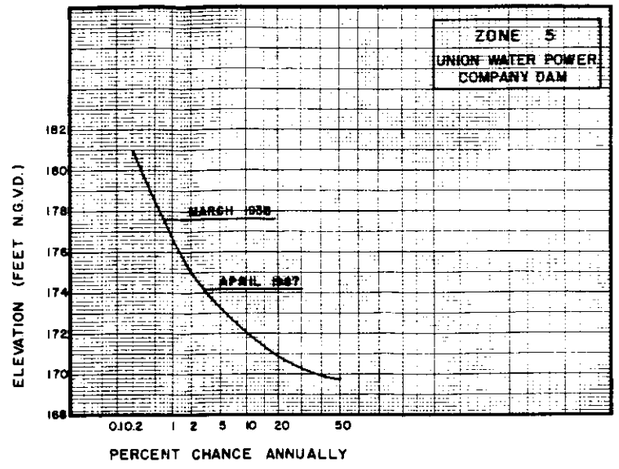
STAGE FREQUENCY CURVES

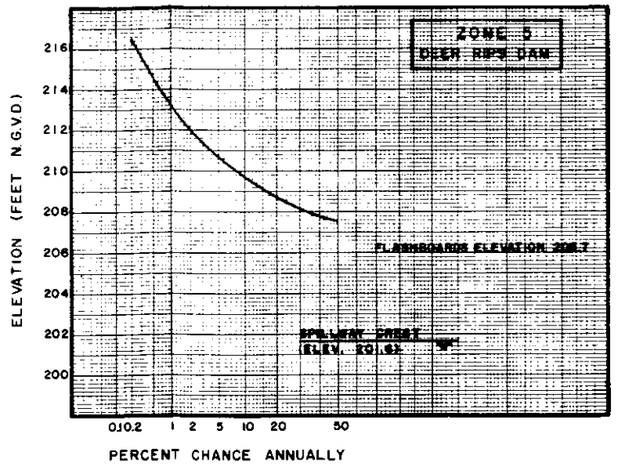
ANDROSCOGGIN RIVER

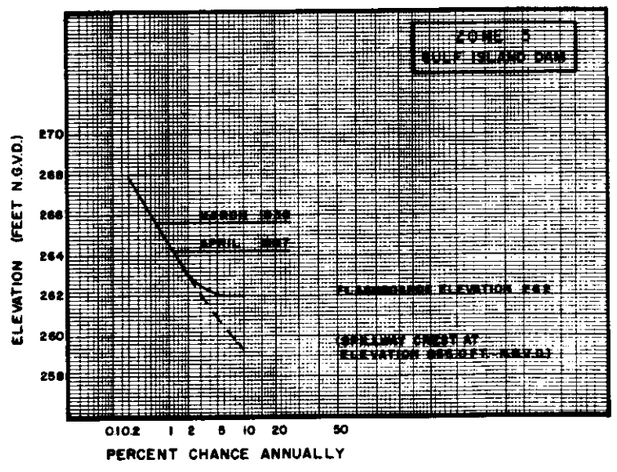
HES JAN. 1989

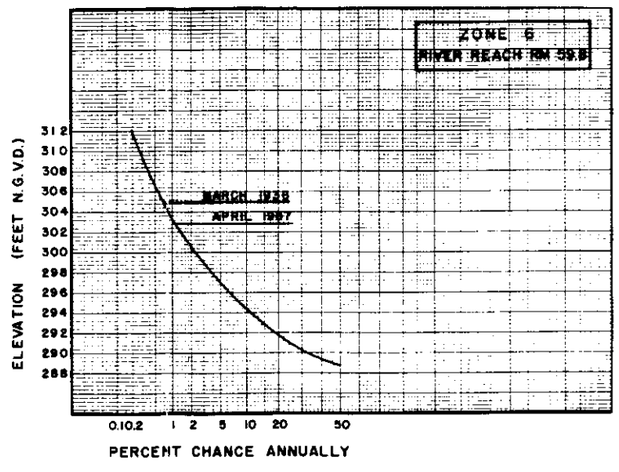
PLATE 9a

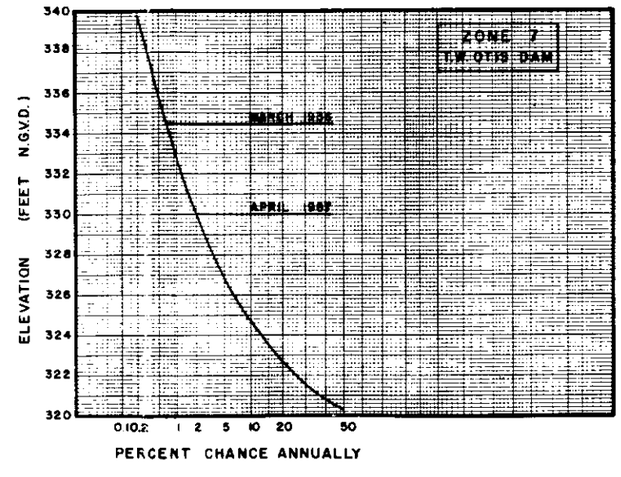


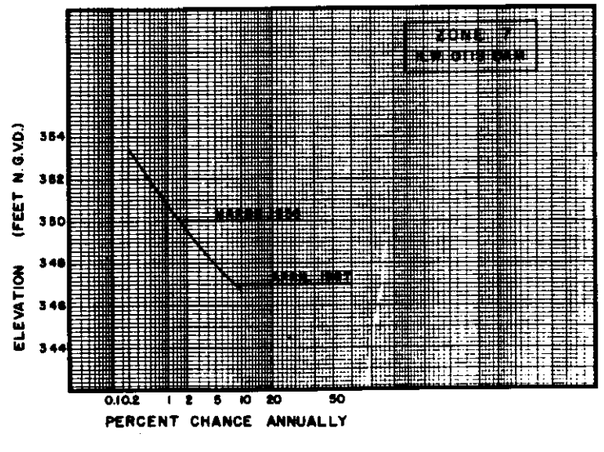


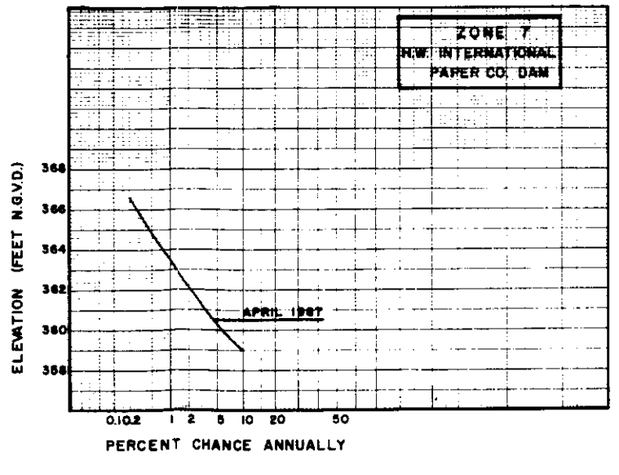












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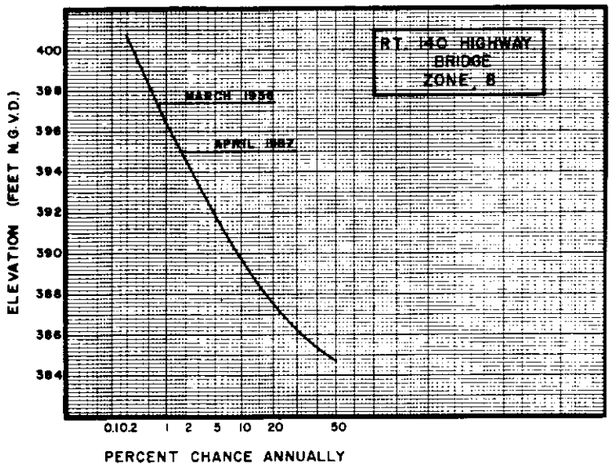
STAGE FREQUENCY CURVES

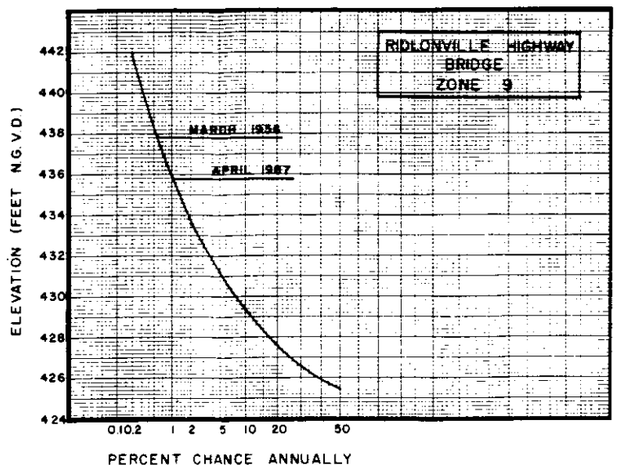
ANDROSCOGGIN RIVER

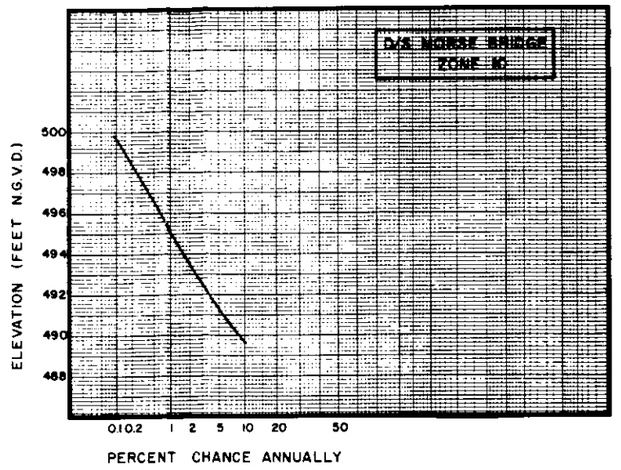
HES

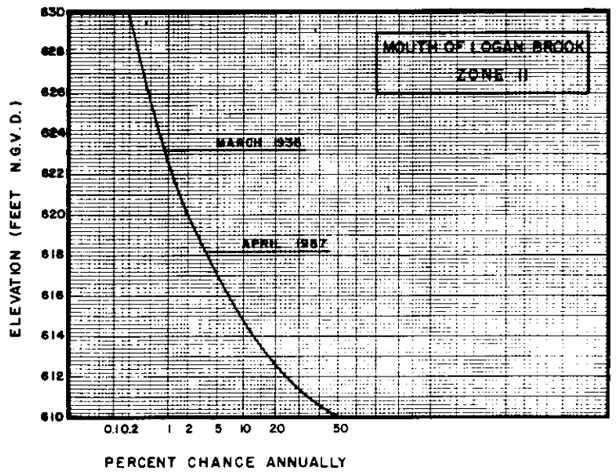
JAN. 1969

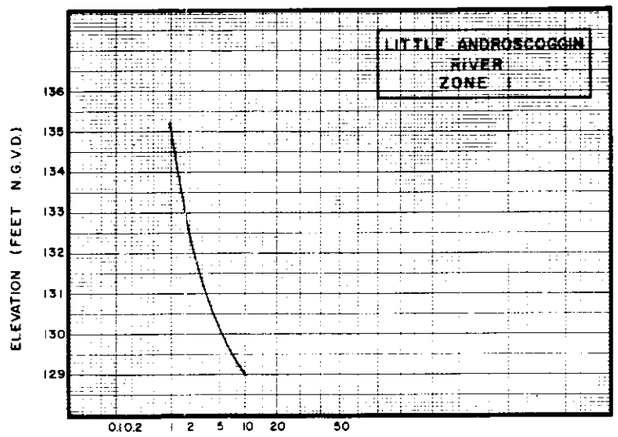
PLATE 9b

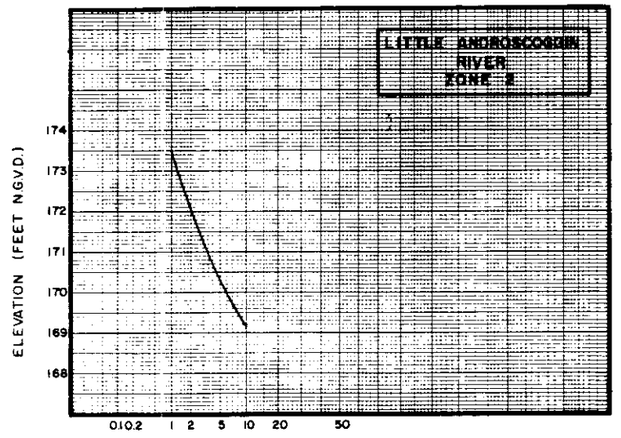


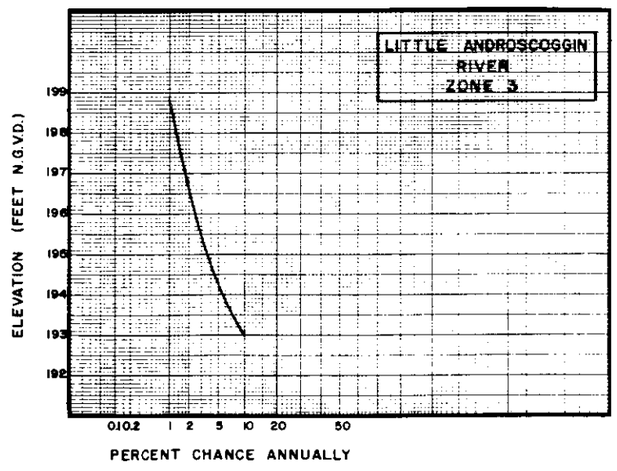


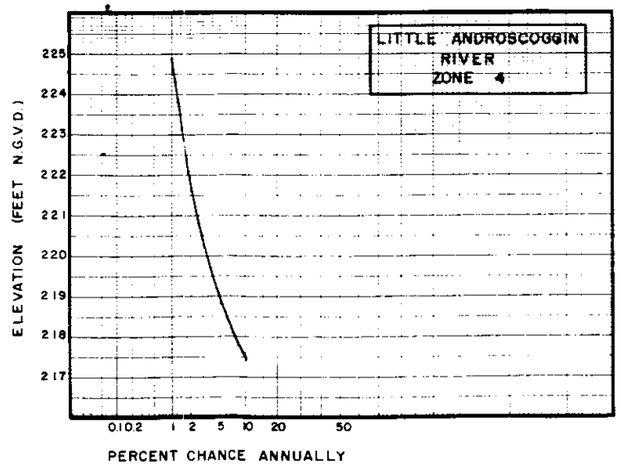












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STAGE FREQUENCY CURVES

ANDROSCOGGIN AND LITTLE ANDROSCOGGIN RIVERS

HES JAN. 1969

PLATE 9c

TABLE 7 (Cont'd)

ELEVATION-FREQUENCY DATA
ANDROSCOGGIN RIVER

River Mile	Zone	Location	Elevations (Feet NGVD) 2-Year	10-Year	50-Year	100-Year	500-Year	1936	1987
61.78	(7) International Paper Co. Dam, RM 60.9 to Riley Dam, International Paper Co., RM 66.6	T.W. Otis Dam, International Paper Co.	320.2	324.8	330.2	332.7	339.8	334.5	330.0
63.6	(7) As above	H.W. Otis Dam	-	346.6	349.6	350.8	353.4	350.0	347.0
63.8	(7) As above	H.W. International Paper Co	-	359.0	362.2	363.4	366.6	-	360.5
71.7	(8) Riley Dam, RM 66.6 to mouth, Webb River, RM 81.8	Route 140 Highway bridge	384.7	389.8	394.6	396.4	400.8	397.4	395.0
85.75	(9) Mouth, Webb River, RM 81.8 to mouth, Swift River, RM 86.3	Ridlonville Highway bridge	425.4	429.3	433.7	435.9	441.9	437.8	435.8
87.1	(10) Mouth, Swift River, RM 86.3 to Route 120 Highway bridge, Rumford, RM 87.6	D/S Morse bridge	-	489.8	493.6	495.3	499.8	-	-
88.05	(11) Route 120 Highway bridge, RM 87.6 to mouth Concord River, RM 95	Mouth of Logan Brook	610.0	614.7	620.1	622.6	629.6	623.1	618.2
		LITTLE ANDROSCOGGIN RIVER							
0.4	(1) Mouth, Little Androscoggin to D/S face Barker Mills Dam, RM 0.0 - 0.72		-	129.0	132.5	135.2	-	140.6*	-
0.95	(2) From Barker Mills Dam to Breached Dam, RM 0.72 - 1.33		-	169.2	172.0	173.5	-	176.3*	-
1.70	(3) From Breached Dam to former USGS gage, RM 1.33 - 5.1		-	193.0	197.0	198.8	-	200.9	-
5.13	(4) From former USGS gage site to U/S corporate limit, RM 5.1 - 8.1		-	217.5	221.8	224.9	-	-	-

*High watermark elevations appear high - validity questioned

ENVIRONMENTAL RESOURCES

Water Quality

Waters of the Upper Drainage of the Androscoggin River (that portion within the State of Maine lying above the rivers' most upstream crossing of the Maine-New Hampshire boundary) and tributary streams are Class A except for Rapid River which is rated Class B.

Umbagog Lake and the Androscoggin River up to Berlin, New Hampshire are Class B. The portion of the Androscoggin River from Berlin to the Maine-New Hampshire border is Class C. Horn Brooks and Bean Brook are Class A at their headwaters with the remainder Class B.

The State of Maine (Maine DEP 1987) classifies the main stem Androscoggin River, including all impoundments, from the Maine-New Hampshire boundary to a line formed by the extension of the Bath-Brunswick boundary across Merrymeeting Bay as Class C. At certain times portions of the waters in the impoundments created by Gulf Island, Deer Rips, and Lewiston Falls Dams do not meet the Class C requirements for aquatic life and dissolved oxygen. Because of the value of hydropower energy to the state these impoundments are considered to meet their classification if the DEP finds that conditions in these impoundments are not preventing their designated uses from being reasonably attained.

The Little Androscoggin River is alternately classified B and Class C along its length. All of its major tributaries are Class C.

Aquatic & Biological Resources

a. General

The Maine Department of Inland Fisheries and Wildlife (MDIFW 1985) has divided the state into seven Fisheries Management Regions. The Androscoggin River Basin is located within the Rangeley (D), Sebago (A), and Belgrade (B) Regions (Figure 10). Fisheries within the basin change a great deal from north to south. The upper basin supports mostly naturally reproducing salmonids while the more southern reaches support mostly put and take salmonids and warm water fisheries.

Seven reservoirs in addition to a number of other run of the river storage facilities are being considered for re-regulation. One of these is located entirely in New Hampshire, Pontook Reservoir, and one, Umbagog Lake, is located on the New Hampshire-Maine border. The remaining lakes, Aziscohos, Mooselookmeguntic, Rangeley, Upper and Lower Richardson, and Gulf Island are located in Maine. Five of the lakes, Kennebago, Rangeley, Upper and Lower Richardson, Mooselookmeguntic, and Aziscohos are part of the Rangeley Lakes which is one of the most important fishing regions of inland Maine. These lakes support similar species of fish with naturally reproducing populations of brook trout (Salvelinus fontinalis) and landlocked salmon (Salmo sebago) sharing the greatest importance. Kennebago, Rangeley, and Mooselookmeguntic have the best fisheries for these species, due to the availability of excellent spawning tributaries and the relatively small water level fluctuations. Richardson Lakes offer a high quality fishery also, however growth rates for salmon are somewhat lower.

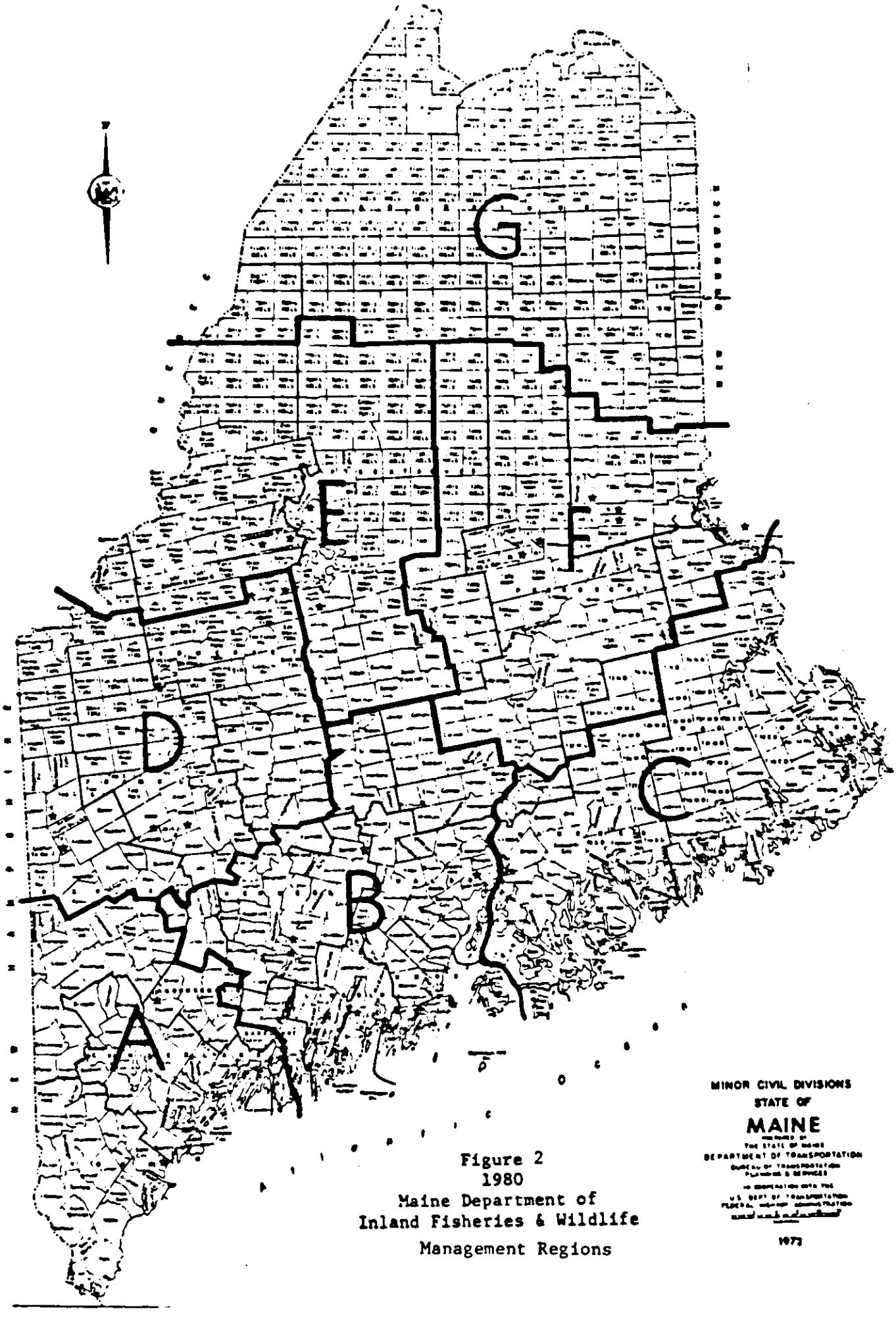


Figure 2
1980
Maine Department of
Inland Fisheries & Wildlife
Management Regions

Figure 10

A general list of fish species of the Rangeley Lakes is shown on Table 8. Brown trout have also been introduced and are rare (PAL). Umbagog Lake supports a warm water fishery as well, which includes chain pickerel (Esox niger), horned pout (Ameiurus nebulasussp), yellow perch (Perca flavescens), and whitefish (Coregonus). The three major fish species which reproduce naturally in the Androscoggin River Basin are landlocked salmon, brook trout, and smallmouth bass. Brief descriptions of their spawning habits from "Planning for Maine's Inland Fish and Wildlife", Volume II, Part 1 prepared by the Maine Department of Inland Fisheries and Wildlife (1985) follow. The potential to impact fish through water level manipulation is greatest during spawning.

Landlocked salmon spawn in the fall in lake inlets or outlets. The young hatch in early spring and remain in stream "nursery" areas 1 or 2 years before moving into lake habitat, where they soon begin to feed on fish, primarily smelts, and grow much more rapidly. Salmon in most Maine lakes reach legal size (14 inches) in their third, fourth, or fifth year of life.

Brook trout normally spawn in the flowing waters of brooks or streams; the act occurring in the fall (usually October to November). However, shore spawning occurs commonly in some ponds under certain conditions. The presence of springs and ground water inflows appears to be the over-riding factor which determines occurrence of shore spawning. Success of shore spawning is highly variable among different ponds.

The brook trout's basic habitat requirements are cool, well-oxygenated water and suitable spawning sites. As long as water temperatures do not exceed about 68oF. for long periods and oxygen values remain about 5 p.p.m., the brook trout can usually survive and grow. A brook trout may spend any part or all of its life in habitats ranging from the smallest brook to the largest of lakes. In addition, they are capable of spending portions of their lives in marine or brackish waters; although they cannot spawn there.

Smallmouth bass thrive in lakes and ponds with clean;fertile water. Suitable shoreline spawning gravel and stable water levels are also important. Smallmouth bass spawn in the late spring and early summer.

Rainbow smelt are the primary forage species. They spawn in the spring (end of April) for 2-4 weeks in tributaries but not far from the lake.

b. Lake Descriptions

Umbagog Lake

Umbagog Lake is a natural lake with a water level raised by damming. Its area is 7,850 acres, 4,532 acres of which lie in New Hampshire. Its maximum depth is approximately 48 feet in the vicinity of the Rapid River inlet in Maine. The bottom is a mixture of mud, rock and sand and the shoreline consists of sand, gravel and cobble. Submergent vegetation was described as common from a survey by the New Hampshire Fish and Game (New Hampshire Fish and Game 1972). The shallow portions of the lake provide a warm water fishery and the northeastern embayment in Maine provides a cold water fishery. Most of the lake shoreline appears to be upland dominated

TABLE 8

TABLE 1 The distribution of different species of fishes in the Rangeley lakes and their tributaries, as determined from seine collections made by the present survey. An X indicates that the species was found to be present

Kind of fish	Lower Richardson Lake	Lake and tributaries: Upper Richardson Lake	Metallark Bk.	Mosquito Bk.	Beaver Bk.	Lake and tributaries: Moosehorn stream and Cupsuptic lakes	Bema Stream	Cupsuptic R.	Toothaker Bk., trib. of Cupsuptic R.	Kennebago R.	Lake and tributaries: Rangeley Lake	South Bog Stream	Dodge Pond Stream	Long Pond Stream	Lake and tributaries: Kennebago Lake	Wilbur Br.	Big Sag Bk.	Little Kennebago R.	Lake and tributaries: Aziscoos Lake	Little Magalloway R.	Magalloway R.
Smelt *Osmerus mordax*	X	X				X					X								X		
Land-locked Salmon *Salmo salar*			X							X	X		X					X			
Brook Trout *Salvelinus f. fontinalis*			X	X			X	X	X	X		X		X		X	X	X			
Common Sucker *Catostomus c. commersonii*	X	X			X	X				X	X	X	X							X	X
Fine-scaled Sucker *Catostomus c. catostomus*											X	X									
Lake Chub *Couesius plumbeus*	X	X									X	X	X		X			X	X		X
Black-nosed Dace *Rhinichthys a. atratulus*								X		X	X	X	X		X		X	X	X	X	X
Fallfish *Leuciscus corporalis*	X	X	X		X		X			X	X		X						X		X
Creek Chub *Semotilus a. atromaculatus*					X					X			X							X	
Northern Dace *Margariscus m. nachtriebi*	X	X				X															
Fine-scaled Dace *Pfrille neogaea*		X			X																
Red-bellied Dace *Chrosomus eos*		X			X	X							X						X	X	X
Black-nosed Shiner *Notropis h. heterodon*											X		X								
Common Shiner *Notropis c. cornutus*		X			X					X	X	X	X								
Fat-headed Minnow *Pimephales p. promelas*	X	X				X															
Hullhead or Horned Pout *Ameiurus n. nebulosus*		X			X																
Fresh-water Sculpin *Cottus cognatus*												X								X	

From: "A Biological Survey of the Rangeley Lakes, with Special Reference to the Trout and Salmon" by Gerald P. Cooper 1940.

by forest species typical of the area: balsam fir, white pine, and white birch. Portions of the shoreline support pockets of forested and shrub wetlands dominated by deciduous trees and shrubs and in some areas a fringe of emergent sedge wetland is present.

Aziscohos Lake

Aziscohos Lake is the only entirely artificial reservoir of the Rangeley Lakes. It was created by damming the Magalloway River at Wilson's Mills. It is approximately 6,700 acres in area with a maximum depth of approximately 50 feet. The shoreline of Black Brook Cove, observed during the November 1988 site visit, was composed of cobbles. Shoreline vegetation was dominated by red spruce and white pine. The water level was down about seven feet during the site visit and growth of sedges along the exposed cobble shoreline suggests that the low water level is maintained over a long duration.

Aziscohos Lake has the poorest cold water reservoir fishery relative to the other upper lakes. This is due to extreme water level fluctuations and to poor water quality in the summer months which results from stratification and low dissolved oxygen levels. Salmonids move out of the Aziscohos Lake and into the Magalloway River and other tributaries during the late summer months to seek refuge from stressful water quality conditions.

Richardson Lakes

Upper and Lower Richardson Lakes make up approximately 2,900 and 4,200 acres respectively. The maximum depth of these lakes is approximately 100 feet. The water level at the Mill Brook inlet was down approximately five feet during the November 1988 site visit. The exposed shoreline spanned as much as 60 lateral feet and was composed of boulders and gravel grading into sand toward the water. Surrounding upland vegetation consisted of red spruce, white pine, and birch.

Lake trout have been introduced into Richardson Lakes by the Maine Department of Inland Fisheries and Wildlife. There is no evidence of successful reproduction. This is presently not considered to be a problem as it allows the State to carefully manage the species by stocking without risk of excessive competition with native salmonids.

Mooselookmeguntic Lake

Mooselookmeguntic Lake and Cupsuptic Lake, together, are the largest of the Rangeley Lakes at 16,300 acres. Cupsuptic Lake is essentially the northernmost bay of Mooselookmeguntic Lake separated from the remainder of the lake by a shallow area near the Kennebago River and Rangeley Stream inlets. The maximum depth of these lakes is approximately 130 feet. Mooselookmeguntic Lake, along with Kennebago Lake and Rangeley Lake, has the best brook trout and landlocked salmon fishery of the Rangeley Lakes.

The water level at Mooselookmeguntic Lake was low during the November 1988 site visit, exposing a grassy rim between the open water and the upland shoreline. Upland vegetation was dominated by white pine, Northern white cedar, red spruce and birch. Shrub wetlands were also present and separated from the open water.

Rangeley Lake

Rangeley Lake is a 6,000 acre impoundment with a maximum depth of approximately 150 feet. The water level at this lake during the November 1988 site visit appeared to be near normal. Lesser water level fluctuations at this lake are credited with contributing to increased quality of the brook trout and landlocked salmon fisheries. Extensive emergent and scrub/shrub (bog) wetlands present along the Rangeley Lake shoreline are also benefited by a stable water level.

Rangeley Lake has an excellent landlocked salmon and brook trout fishery. Several landlocked salmon nests were observed at the dam by Route 4 during the site visit.

The upland shoreline and surrounding vegetation of Rangeley Lake includes Northern white cedar, hemlock, red spruce, yellow, white, gray and black birch, striped maple, aspen, and white pine.

c. Riverine and Run of the River Habitats

The flow of the Androscoggin River is interrupted numerous times along its length by dams. Where unimpeded by dams the river's flow is rapid with few riverside wetlands. The northern sections of the river, generally above Berlin, New Hampshire, are characterized by fairly shallow rapidly flowing riffles and emergent boulders. The bordering upland habitat is dominated by coniferous forest. More southerly portions of the river are deeper and wider with steep low banks. The bordering upland vegetation here is dominated by gray birch, red maple, oaks, and white pine.

In the vicinity of dams lake-like conditions exist. Fisheries change from cold water species dominance to warm water species, which are generally considered to be of lower quality. Several dam sites were visited in the field including Pontook Dam, two dams in Gorham, New Hampshire, one dam in Shelburne, NH, two dams in Berlin, NH, one dam at Lisbon Falls, Maine, and a dam at Rumford-Mexico, Maine. The dams at Berlin and Rumford-Mexico are surrounded by dense industrial development and support little surrounding natural habitat. At sites where heavy industrial development is absent and slopes are suitable scrub-shrub and emergent wetlands often are present.

The portion of the Androscoggin River below Brunswick Dam which is open to MerryMeeting Bay appears to support more frequent riparian wetlands than other portions of the river. The entrance to the bay up to about West Chops Point is classified as Riverine by the US Fish and Wildlife Service, National Wetlands Inventory. The estuarine limits are located at the entrance and east of Chops.

d. Major Impoundments and Mainstream Fisheries

Two major run of the river reservoirs are present on the Androscoggin River. These are the Pontook Reservoir in Dummer, New Hampshire and Gulf Island Pond in Lewiston and Auburn, Maine. Both of these rivers change the character of the affected portion of the Androscoggin River significantly. The effects of other smaller dams on the character of the river are similar but lesser.

Pontook Reservoir is a 96 acre artificial pond. It is located on the Androscoggin River and

was created by a dam installed for logging purposes. Its maximum depth is 15 feet with an average depth of five feet and transparency to four feet as of a 1952 survey. The bottom was 80 percent muck and 20 percent rock. The wetlands surrounding the reservoir upstream of the dam include extensive emergent wetlands dominated by sedges and shrub/scrub wetlands dominated by alder. Submergent aquatic vegetation was described as abundant after the 1952 survey. The uplands surrounding Pontook Reservoir are dominated by white birch and white spruce.

The Pontook Reservoir is primarily a warm water fishery supporting black bass, chain pickerel, and yellow perch. Additionally the New Hampshire Department of Fish and Game stocks brook, brown, and rainbow trout annually in the vicinity of the Pontook Hydroelectric Project. There is relatively little recent information available for fisheries in the New Hampshire portion of the Androscoggin River basin but this basin as well as the rest of northern New Hampshire is receiving increasing emphasis.

Gulf Island Pond was created by the construction of a dam on the mainstem Androscoggin River about three miles north of Lewiston-Auburn. The pond, essentially, retains its riverine linear form as does the Pontook Reservoir. Water quality is depressed in the pond compared to the surrounding riverine habitats. Because of the lesser water quality Gulf Island Pond supports a predominantly warm water fishery with only occasional trout. The major gamefish and panfish are largemouth bass, brown bullhead, pickerel, and yellow perch.

The mainstem Androscoggin River supports very productive warm and cold water fisheries. Above Berlin, New Hampshire the major fish species are brook trout, brown trout, rainbow trout, landlocked salmon, chain pickerel, yellow perch, and smallmouth bass. The New Hampshire Department of Fish and Game stocks put and take brook and rainbow trout and put and grow brown trout and landlocked salmon. Below Berlin, the rainbow trout fishery is maintained to same degree by natural reproduction. There is considerable natural brook and rainbow trout reproduction from the tributaries contributed to the Androscoggin River but high flows limit spawning in the mainstem river.

The lower mainstem Androscoggin River supports predominantly stocked brown trout. Other salmonids, largemouth bass, and an excellent smallmouth bass fishery are also present.

Anadromous fish in the Androscoggin River are confined to the reach below Lewiston Falls, the historical limit of anadromous species except Atlantic salmon. Maine is currently in the process of restoring anadromous fish runs in the Androscoggin Basin. Since 1983, alewives, American shad, sea run brown and brook trout, and Atlantic salmon have been trapped at the Brunswick dam and trucked to mainstem and tributary sites below Lewiston Falls. The Maine Department of Marine Resources is currently stocking alewives in lakes and ponds throughout the Little Androscoggin River basin. They will be stocking shad in the basin as they are collected at Brunswick or transferred from other rivers. American shad spawn from mid-May through June and the river serves as a nursery till fall. Three dams are in place on the Little Androscoggin River. Two of these have fish passage structures and a structure is under construction on the third.

The Sabbatus River was stocked with alewives in the past but this program is presently on hold. Restoration to the Sabbatus River is still part of the State restoration program. Atlantic salmon historically occurred in the Nezinscot River, but no plans exist to restore this species to the river in the near future.

The mouth of the Androscoggin River at Merrymeeting Bay is used by smelt, striped bass (Morone saxatilis), and sea run brown and brook trout, and short nosed sturgeon (Acipenser brevirostrum).

Wetland Resources

In general the mainstem Androscoggin River supports few riparian wetlands except where its flow is constricted as at the numerous dams along its length and at the lower extremes of the river. The majority of the river would be classified as Riverine-Upper Perennial-Rock Bottom according to the U.S. Fish and Wildlife Service classification system because of its rapid flow and limited floodplain. The tributaries to the Androscoggin River appear to support more wetlands than the mainstem river. The subclasses and dominance types of wetlands in the basin vary from north to south. The northern wetlands of the Rangeley Lakes region appeared to be most of ten dominated by needle-leaved evergreen and deciduous forested wetlands, broad-leaved deciduous scrub-shrub wetlands, and persistent emergent wetlands. Dominance types includes northern white cedar, black spruce, and larch in forested wetlands; speckled alder, sweet gale, and leatherleaf in scrub-shrub wetlands; and sedges an emergent wetlands.

TABLE 9

Wetland Plants Observed DuringAndroscoggin River Basin Field Investigations (November 2, 3, 4, 1988).

Trees	
Acer rubrum	Red maple
Betula populifolia	Gray birch
Fraxinus sp	Ash
Ulmus sp	Elm
Thuja occidentalis	Northern white cedar
Picea	Black spruce
Abies balsamea	Balsam fir
Larix laricina	Tamarack
Shrubs	
Alnus rugosa	Speckled alder
Salix nigra	Black willow
Cornus amomum	Silky dogwood
Spirea latifolia	Meadowsweet
Rosa palustris	Swamp rose
Chamaedaphne calyculata	Leatherleaf
Myrica gale	Sweet gale
Kalmia angustifolia	Sheep laurel
Rhododendron viscosum	Swamp azalea
Andromeda glaucophylla	Bog-rosemary
Viburnum cassinoides	Wild raisin
Viburnum recognitum	Arrow-wood
Ilex verticillata	Winterberry
Salix discolor	Pussywillow
Emergents	
Glyceria sp.	Manna grass
Phalaris arundinacpa	Reed canary grass
Carex stricta	Tussock sedge
Carex spp.	Sedge
Onoclea sensibilis	Sensitive fern
Osmunda cinnamomea	Cinimom fern
Osmunda regalis	Royal fern
Scirpus cyperinus	Woolgrass
Equisetum sp.	Horsetail
Eleocharis sp.	Spike rush
Typha sp.	Cattail
Calamagrostis sp.	Bentgrass
Other	
Sphagnum sp.	Sphagnum moss

Just south of Umbagog Lake to about Pontook Reservoir wetlands associated with the Androscoggin River are transitional between the upper and lower basin. Wetlands of the southern portions of the basin appear to most frequently fall within the broad-leaved deciduous forested and scrub-shrub wetland and persistent emergent wetland classes and subclasses. Dominance types most often consisted of red maple forest, speckled alder and meadowsweat scrub-shrub plants, and a variety of emergent species.

The wetlands of the Androscoggin River system, in general, have high wildlife value because, by definition, they are associated with lake open water or riverine habitat. In addition, since much of the basin has little human development, especially the Rangeley Lakes region, the value of the wetlands is enhanced by adjacent natural upland habitat types. Wetlands identified as having especially high wildlife value are the wetland complex at the outlet of Kennebago Lake, the Umbagog Lake wetland complex, the wetland surrounding the Dead River outlet of Androscoggin Lake, wetlands on the Nezinscot River at the dam in Turner, and seven wetlands on the Little Androscoggin River rated as having high wildlife value. Wetland plants observed in the basin are listed on Table 9.

Wetlands can be found at all of the Rangeley lakes, however, wetland distribution varies widely. The shorelines of the lakes are generally rocky with upland vegetation extending to the waters edge. Lake water level fluctuation is a major factor limiting emergent wetland formation on the Rangeley Lakes. With the exception of Umbagog Lake, emergent wetlands are primarily found in the lower energy environments within coves or at the mouth of tributaries, e.g., Metallak Brook on Upper Richardson Lake and South Bog Stream on Rangeley Lake. In some cases, as on Richardson Lake near the Mooselookmeguntic Dam, scrub-shrub or forested wetlands are present on the shoreline edge or at the entrance of tributary streams but separated from the open water by exposed shoreline. This suggests that these wetlands may be dependent on upland surface, soil, or groundwater rather than lake water levels or that the current water management regime is sufficient to maintain these wetland types. Sedges and grasses growing between the vegetation line and open water suggest that water levels in these areas have been low for much of the growing season.

Scrub-shrub and emergent wetlands are present at most of the mainstem impoundments. Dominant plants in the wetlands are the tall shrub, speckled alder, or a variety of emergent plants.

In addition to the Androscoggin River, the Webb, Ellis, Sabbatus, Swift, Nezinscot, and Little Androscoggin Rivers, have significant wetland areas within their drainages. Most of the headwater lakes and ponds, particularly Webb Lake and Androscoggin Lake, have peripheral wetlands that are important for wildlife. Gulf Island Pond has limited associated wetlands as a result of its pronounced water level fluctuations. Habitat evaluation studies are underway as part of the FERC relicensing process to quantify the effect of water level fluctuations on wetlands and wildlife communities at the Gulf Island Dam Project.

Terrestrial Resources and Wildlife

a. Forest Resources

The Androscoggin River Basin falls within the Northern Hardwoods Forest Region also described as the hemlock-white-pine- northern hardwoods region or beech-birch-maple-hemlock type. The principal tree species of this region are listed in Table 10.

Red maple, white birch, oaks, and white pine are most common in southern positions of the basin. In northern portions of the basin balsam fir, red spruce, hemlock, white pine, and white birch are common. The upper Androscoggin River Basin in the Rangeley Lakes Region contains extensive softwood, hardwood, and mixed timber stands. Timber harvesting is the primary land use with balsam fir, red spruce and yellow birch among the important commercial tree species.

b. Wildlife

The Rangeley Lakes region is relatively undeveloped and provides high quality habitat for a variety of wildlife species. White-tailed deer are one of the most important game species in the area. Moose are also common. Other mammals likely to occur in the study area include: black bear, coyote, red fox, bobcat, fisher, marten, weasel, river otter, mink, raccoon, striped skunk, musckrat, beaver, porcupine, snowshoe hare, red squirrel, and small mammals such as shrews, mice and voles. Wildlife observed during the November 1988 site visit by the Corps and Fish and Wildlife Service include bobcat, moose, common loon, bufflehead, common merganser, hooded merganser, bluejay, snow bunting, junco, chickadee, ruffed grouse, great blue heron, red squirrel, red- tailed hawk, osprey, Cooper's hawk, raven, crow, and ring-billed gull.

Semi-aquatic furbearers such as otter, mink, muskrat, and beaver are uncommon in the Rangeley Lakes except for Lake Umbagog due to the adverse consequences of lake water level fluctuations. Large water level fluctuations do not provide stable conditions for the establishment of emergent and submergent aquatic vegetation which provides food and cover for fish and wildlife. The "ring" of unvegetated area between open water and upland vegetation creates conditions unfavorable for the establishment of animal dens. Water level fluctuations also adversely affect loon and waterfowl nesting.

The wildlife component of habitat is highly reflective of and dependent on the vegetation and physical components of the habitat. Therefore, the value of wildlife habitat is assessed based on these qualities. Descriptions of important habitat areas identified at the reconnaissance level follow.

A number of unique wildlife areas are found in the Rangeley Lakes region. There is a very high quality wetland complex at the outlet of Kennebago Lake that supports excellent waterfowl production. The Kennebago River has been designated a Class "B" river in the Maine Rivers Study, denoting outstanding statewide resource values. Resource values specifically identified in the Study include: high quality wetlands important to waterfowl and furbearers; a major white-tailed

TABLE 10
Important Species of the Northern Hardwoods Region

Region Scientific Name	Common Name
Fagus grandifolia	American beech
Betula allegheniensis	Yellow birch
Acer saccharum	Sugar maple
Tsuga canadensis	Eastern hemlock
Pinus strobus	Eastern white pine
Acer rubrum	Red maple
Pinus resinosa	Red pine
Populus grandidentata	Bigtooth aspen
Quercus rubra	Northern red oak
Fraxinus americana	White ash
Ulmus americana	American elm
Thuja accidentalis	Northern white cedar
Tilia americana	American basswood
Prunus serotina	Black cherry
Picea rubens	Red spruce
Pinus banksiana	Jack pine (Young 1982)
Betula papyrifera	Paper birch
Picea glauca	White spruce
Populus tremuloides	Quaking aspen
Picea mariana	Black spruce
Larix laricina	Tamarack
Abies balsamea	Balsam fir
Pinus banksiana	Jack pine

deer wintering area near the mouth of Kamankeag Stream: as well as one of Maine's most outstanding inland fishing rivers for native brook trout and landlocked salmon.

The Rapid River, which flows six miles from Middle Dam to Umbagog Lake, has also been designated a Class "B" river in the Maine Rivers Study. Outstanding resource values include: a major deer wintering area along the river; important loon nesting islands at the mouth of the river in Umbagog Lake; significant brook trout and landlocked salmon resources; and one of the highest quality and most popular white water boating runs in the state. The Rapid River White Water Rapids are also designated as a State Registered Critical Area due to the high white water boating values and presence of a unique old-growth white pine stand along its banks. This stand is the largest stand of virgin pine and has the largest average tree size of any pine stand in the state.

Umbagog Lake was included in the Fish and Wildlife Service's 1979 Unique Ecosystem Concept Plan. The lake is considered one of the finest waterfowl areas in New Hampshire and is one of the most important breeding grounds for common loon in the northeast. Loon breeding habitat here is considered to be significant and unique due to the high habitat diversity and lack of disturbance. There are over 8000 acres of prime black duck nesting habitat within the Umbagog Lake wetland complex. Other waterfowl species that commonly breed in and around the reservoir include: goldeneye, ring-neck duck, wood duck, hooded merganser, and common merganser. Ruffed grouse, snipe, and woodcock are among the important upland game birds in the area. There is a great blue heron rookery that supports 20 to 30 heron pairs. Both Aziscohos and Richardson Lakes also have heron rookeries. The rookery on Aziscohos is on an island and could be affected if water levels are increased, causing the nesting trees to die. There are six active osprey nests and one inactive bald eagle nest. Umbagog Lake has the only breeding colony of ring-billed gulls in Maine. It is the one reservoir in the Rangeley Lakes area that supports significant populations of furbearers, due primarily to more stable water levels which allow aquatic vegetation to flourish.

All of the Rangeley Lakes have resident loons. The primary factor limiting loon production on all of the reservoirs is water level fluctuations during the critical nesting period. Loons must nest at the waters edge since their body is adapted for swimming and they cannot walk upright on land. A rise in lake water levels as little as 0.5 feet can inundate the nest and destroy the clutch. Decreasing water levels expose shoreline between the nest and the waters edge, and thus prevent the birds from reaching the nest to protect and incubate the eggs. The effect of declining water levels is dependent on the slope of the shoreline. Drops of 1.5 vertical feet or less can be sufficient to prevent access by adult birds and thus cause nest failure. Attention has been focused on the Aziscohos Lake Loon population as part of the FERC license proceedings. A comprehensive study of loon nesting documented 26 resident loons on the lake. Ten nesting pair were recorded in 1987. Because of the severe consequences of lake level fluctuation, artificial loon nesting islands are being experimentally evaluated as a condition of the FERC license. There are many site-specific factors that affect the potential success of artificial nesting islands. Generally, they are considered to be of limited usefulness in mitigating the adverse effects of water level fluctuations. Peter Cross of the Maine Department of Inland Fisheries and Wildlife indicated that the initial results of these experimental nesting efforts showed reasonably good success, but that alot of maintenance and monitoring is required. During later study phases it will be necessary to assess impacts to loons and potential mitigation if the water level management alternatives remain. The Loon Preservation Committee would be contacted at that time.

The mainstem Androscoggin River and tributaries downstream of the Rangeley Lakes appear to have high wildlife value in undeveloped areas. A thorough inventory of specific sites has not been completed for the water resources study however several particularly valuable areas have been identified by the Maine Department of Inland Fisheries and Wildlife and the U.S. Fish and Wildlife Service.

Wetlands on the Little Androscoggin River and Nezinscot River in Region A have been rated for their value to waterfowl. There are seven high value wetlands, six moderate value wetlands, and six low value wetlands on the Little Androscoggin River and its tributaries. On the Nezinscot River in Region A there is one high value wetland, two moderate value wetlands, and one low value wetland. There are also two historic deer wintering areas (these areas have not been surveyed in 8-10 years) on the Nezinscot River. One is located at Russel Brook in Sumner and the other is located at Jersey Bog in Buckfield.

In Region B, the Nezinscot River is described as valuable for waterfowl west of Route 4 with very high value at the dam in Turner. Its value also increases at its junction with the Androscoggin River.

Dead River and its source, Androscoggin Lake, are described as having high wildlife value. Slow moving portions of the river are valuable for furbearers and waterfowl. Androscoggin Lake, especially at the outlet, where a peninsular of marsh extends into the lake is valuable for wildlife. The lake receives significant waterfowl use, attracting species such as redheads and pintails that are not commonly found on other lakes in the region. Perimeter wetlands are important for waterfowl and loon production. Lothrup Island supports a major heron rookery, as well as an active osprey nest and an inactive bald eagle nest.

The Sabbatus River is described as having high quality habitat for waterfowl, furbearers and shorebirds from the Androscoggin River north to Route 126.

The western shore of Gulf Island Pond from Twitchell Airport north for four miles is undeveloped and has very good riparian habitat. The islands provide good furbearer habitat for species such as raccoon, otter, mink, and beaver. A deer yard is present at Bradford Brook.

Threatened, Rare, and Endangered Species

The U.S. Fish and Wildlife Service has determined that the headwater reaches of the Androscoggin River Basin have sites with a strong potential for nesting by peregrine falcons (Falco peregrinus). Potential aerie (cliff nest) sites are near the mainstem river in the Gilead-Bethel vicinity. Also, the project area includes two historic bald eagle nests that could potentially be used again in the future. These are located at Umbagog Lake and Androscoggin Lake.

HISTORIC AND ARCHAEOLOGICAL RESOURCES

Prehistoric Period

There are several known prehistoric period sites dating from the last 11,000 years recorded along the Androscoggin River from Rumford to Topsham. Information about these sites and human habitation in the Androscoggin River Basin during prehistoric times is fragmentary. However, some inferences can be drawn from the existing data. More information about prehistoric site location has been collected within the last three years, but is not yet generally available. As this data becomes available, a more complete picture of prehistoric human use of the basin will be possible.

The native people of the Androscoggin River were known by the Europeans of the 17th century as the Anasagunticooks. Their hunting grounds covered the entire river valley. In "The History of Androscoggin County, Georgia Merrill reports that..."We are in possession of very little information in relation to the Anasagunticooks - or Androscoggin Indians, as they are subsequently called - before King Philips War in 1675-6. At Brunswick Falls (Topsham) they had an encampment or place of resort and a fort...At Lewiston Falls they frequently rendezvoued, and at an early day had a fort of considerable magnitude. There was a large encampment at Canton, covering the fine interval of that region." The meetings between the Europeans and the Androscoggins were acrimonious. Merrill relates that this Amerindian group was more hostile to the white settlers than any other native group in Maine. "The Androscoggins were the first to `dig up' the tomahawk and the last to `bury' it." As late as 1722, a group of natives landed at Merrymeeting Bay, captured nine families and held several men hostage.

The Anasagunticooks were the last in a long line of Amerindian groups to exploit the resources of the Androscoggin River Basin. The earliest are referred to as Paleoindians. Their sites date from approximately 10,500 B.C. to 8000 B.C., and are recognized by their distinctive stone tool assemblage, which include fluted projectile points. Paleoindians lived in a cold, tundra or spruce parkland environment, and hunted large animals such as caribou. The Archaic period (8000 B.C. to 1500 B.C.) is divided into Early (8000 B.C. to 6000 B.C.), Middle (6000 B.C. to 4000 B.C.) and Late, (4000 B.C. to 1500 B.C.), and are characterized by distinctive projectile point styles and tool assemblages. The Woodland, or Ceramic period (1500 B.C. to A.D. 1600) is also divided into Early (1500 B.C. to 300 B.C.), Middle (300 B.C. to A. D. 1000) and Late (A.D. 1000 to A.D. 1600), and are distinguished by projectile point styles and ceramic styles, as well as mortuary traditions.

A Paleoindian site was identified near Rumford Point at a stream/river confluence. The Michaud site, located near Lewiston, is another identified Paleoindian site (Speiss and Wilson 1987). For the most part, they are on higher terraces, or high outwash plains.

Very few sites from this period have been uncovered in Maine. For the Archaic and early historic periods (1600-1750), several sites have been identified along the Androscoggin River. In particular, the areas around Topsham and Canton have a very high potential for the presence of prehistoric sites.

Prehistoric archaeological sites may be present on many different landforms within the riverine environment. Concentrations of sites occur at tributary stream junctions and falls, but the floodplains and river terraces also may have sites, although some may be buried by alluvial sediment. The Maine Historic Preservation Commission's files contain records of several prehistoric sites in close proximity to nearly all current study areas. Evidence of prehistoric occupation has been unearthed even in urban areas, such as Lewiston and Auburn. The currently known inventory of sites suggest that the River Basin has received nearly continuous use as a habitation/resource exploitation area for at least the past 6000 to 8000 years. Any structural alternative has the potential for disturbing previously unidentified prehistoric sites. Close examination of the geomorphology and compilation of the land use history for the last 350 years will be required before structural alteratives are authorized for construction.

Historic Period

The Androscoggin River has been used as a source of power since the Europeans settled in the river basin in the late 18th century. The early saw and grist mills harnessed some of the energy available, but the water-power potential was not fully exploited until the mid 19th century. An access to the markets of the eastern seaboard was needed as a impetus for industrial development of the area. This was provided by the the arrival of the railroad between 1848 and 1860. Corporations were then organized which controlled and improved the water-powers at Rumford Falls, Lewiston Falls and Lisbon Falls by constructing dams, locks and canals and selling or renting the riparian rights at these areas. By 1900 industrial centers had developed at Rumford, Lewiston, Lisbon and Auburn. The river was providing power for the paper mills, shoe factories and woolen and cotton mills.

Rumford

In 1774 the Commonwealth of Massachusetts granted seven square miles of land along the Androscoggin River to a Timothy Walker Jr. This land, which included part of Rumford, was called New Pennacook. Several families settled in the area between 1774 and 1778, however, Indian raids on the nearby settlement of Bethel caused the settlers to flee the area. The residents of New Pennacook did not return until 1783-84. In 1786, in order to attract more settlers to the area, a bounty of six pounds was offered to anyone who would, within one year move into the area. The population of New Pennacook Plantation was 262 in 1800.

A small saw mill and a grist mill were built on the Rumford Falls in 1780, but the power potential of the falls was not fully exploited until the end of the 19th century. The 1890s were a period of rapid change for Rumford when it was transformed from a small farming community to an industrial town.

Hugh J. Chisholm, a businessman from Portland, visited the area in 1882. Chisholm was so impressed by the water power that in 1883 he had an engineering survey done of Rumford Falls. Between 1882 and 1890, Mr. Chisholm acquired 1400 acres, including the riparian rights to the falls and sufficient land for mill sites, business and residential areas. Detailed plans for the industrial community were developed which included streets, bridges and shopping centers.

By 1890 Hugh Chisholm had acquired the 1400 acres on both sides of the falls and organized

the Rumford Falls Power Company. That same year, construction was started on a dam and canal across the middle falls on the Androscoggin River. At the same time, Chisholm and his associates formed the Portland and Rumford Falls Railway Company. This company bought the unused Rumford Falls and Buckfield Railroad Company which ran as far as Canton. The tracks were extended to Rumford and in August 1892 the first train arrived in Rumford. The town now had access to Portland and the other eastern seaboard cities which was essential for the success of the industrial development in Rumford. In 1894 the Rumford Falls and Rangeley Lakes Railroad Company was organized by Hugh Chisholm. This line provided an access for bringing pulpwood from the Rangeley Lakes area to the mills in Rumford. These railways were leased to the Maine Central Railroad in 1907.

Three mills began operation in 1893; the Rumford Falls Paper Company, the Rumford Falls Sulphite Company and the Electro Chemical Company. The paper and sulphite companies became part of the International Paper Company which Chisholm founded in 1898. In 1899 the Continental Paper Bag Company began operations. Chisholm organized the Oxford Paper Company in 1900 for the manufacture of fine quality paper. Production began at the new mill in 1901.

By 1910 Rumford was established as a center for pulp and paper production. In 1890 the population of the town was 898. By 1910 the town's population had grown to 6777. Hugh Chisholm also developed municipal services for Rumford. He founded the Rumford Falls Light and Water Company to provide electricity and drinking water for the town. In 1901 Chisholm founded the Rumford Realty Company which constructed a large scale housing project for mill workers.

In 1970 the population of the town was 9289. Rumford has basically remained a one industry town. Paper production is still the important industry in Rumford with 338,733 tons of paper produced in 1970.

Mexico

The town of Mexico was part of Township #1, a land grant purchased from Massachusetts in 1789 by Colonel Jonathan Holman. This grant consisted of 30,020 acres on the north side of the Androscoggin River. This area included what are now the towns of Dixfield and Mexico. Seven families settled at the confluence of the Swift River and the Androscoggin River. In 1818 the settlers petitioned the Legislature of the State of Massachusetts to incorporate their area as a town. On 13 February 1818, their settlement became the town of Mexico.

The earliest industries in Township #1 were sawmills. The first saw mill in the area was on Mitchell Brook (near Roxbury). There were two cheese factories, a grist mill and hops industry along the Swift River in the mid 19th century. A saw and grist mill on the west side of the Swift River was in operation until 1869 when it was washed away in a flood. A lumber mill was built at this location after 1870. During the late 19th/early 20th century, a toothpick factory was in operation on the Webb River in Mexico. The factory employed 100 men who produced 1,800,000 toothpicks per day. This factory was located on the site of an earlier mill which manufactured boxes.

Mexico never developed as an industrial town. Most of the community's early industries were small, transient businesses that served local needs. Currently, Rumford's paper industry employs

many of the residents of Mexico.

Peru

Peru was part of a township organized in 1812 as Plantation #1. The area had a population of 341 residents when it was incorporated as the town of Peru in 1821.

The first mill was in operation on the Androscoggin River at Peru Center in the 1820s. This saw and grist mill continued its operations through the early 20th century. Other industries included a corn or grist mill, a wheelwright shop, a woodworking shop and a shingle factory in East Peru. From 1857 to 1904 a saw mill in West Peru produced clapboard, shingles, cabinets and long and short lumber. Arnold's grist mill and the Hall Brothers rake manufactory were also located in West Peru.

Most of these industries were small. The occupation of most residents in Peru was farming and the town's economy was always chiefly based on agriculture.

Canton

The territory which includes the present town of Canton was a part of unappropriated public lands in 1771. Ten families had settled in the area by 1786, with the first saw and grist mills in operation at Canton Village in 1815. The town of Canton was incorporated in 1821.

In 1819 a tannery was built in Canton Village. This business initially employed six to eight hands to tan sheep skins. In 1887 the tannery was enlarged and employed 100 people. Other early industries included George DeCoster's carriage shop and a foundry which produced stoves, plows, mill castings and shingle machines. W. W. Blanchard's feed mill and C. F. Oldham's woodworking shop were also located in Canton Village during the late 19th century. In Gilbertville a large lumber mill and pulp mill were established in 1879-80. These manufactories were located on the Androscoggin River. The Winslow packing company was built in Canton Village in 1881. In 1901 this company packed 500,000 cans of corn annually. Sweet cream was shipped to Boston by the Canton Co-op Creamery Association which was organized in 1899.

Canton developed into a small industrial town with a variety of different industries. Most of the mills and factories were constructed on Whitney Brook, the outlet of Whitney Pond in the southern part of town.

Lewiston

The first settler in the area of Lewiston arrived in 1770. The town was incorporated in 1795 and by 1800 the population was 948. Lumbering was the main industry of the early settlers along with fur trading and the manufacture of potash. During the early to mid 19th century agriculture played an important role in the economy of the town. Sheep and cattle farming were common as were orchards. Lewiston was a prosperous farming town until the development of the water-power of the Lewiston Falls on the Androscoggin River, when it became one of Maine's major manufacturing cities.

Prior to the water-power development, there were only a few mills on Lewiston Falls. The first

saw mill in Lewiston was built in 1770-71. A grist mill was built a few years later. The first dam across the Androscoggin River in Lewiston was constructed in 1809. A saw, grist and fulling mill was built on a canal at this location. This mill was purchased by the Lewiston Falls Manufacturing Company in 1834 and converted into a satinet mill. This mill contained the first looms in Lewiston. In 1836 the town's first cotton mill began operation at the falls. The mill remained in business until partially destroyed by fire in 1850.

On 24 March 1849, the Androscoggin and Kennebec Railroad was opened to Lewiston. In 1860 this railway line formed a junction with the Portland and Kennebec Railroad in Brunswick. this gave Lewiston direct access to Portland and other northeast coast markets.

The Great Androscoggin Falls, Dam, Locks and Canal Company was incorporated on 23 February 1836. This later became known as the Lewiston Water-Power Company. This company was organized to develop the water-power at Lewiston Falls. The corporation owned the water power and much of the land near the falls. In 1864 a large granite dam was built across the falls by the Franklin Company. Other improvements were made at the falls and by 1891 there were four dams, a main canal, several cross canals, locks and seven sluiceways. There were at least ten woolen and cotton mills in operation by 1890. These included the Androscoggin Mills, Bates Manufacturing Company, Continental Mills, Franklin Company and the Lewiston Mills. These manufacturers employed over 5000 people.

The major industries in Lewiston were the woolen and cotton mills. However, there were numerous other manufacturing companies in the city. Many provided services for the mills, producing cotton machinery, bobbins and belts and rollers.

In 1862 Lewiston was incorporated as a city and by 1890 the population was 21,701. This period was the high point of industrial development for the area around Lewiston Falls.

Auburn

The city of Auburn was settled as several distinct villages; Goff's Corner, East Auburn, West Auburn, North Auburn, New Auburn and Steven's Mills. These areas became local business centers. Goff's Corner developed into the downtown of the city proper, being located adjacent to the Androscoggin River at Lewiston Falls.

The first settler arrived in 1797 and constructed a log cabin near what is now the corner of Main and Court Streets. A grist mill was built in 1798 near the falls on what was known as Foundry Brook. The village grew very slowly until the Androscoggin and Kennebec Railroad was opened to the town in 1848. In 1849, Auburn became a part of Lewiston Falls village, but became a separate township in 1854 when it was selected to be the county seat for the newly formed Androscoggin County. In 1850 the population was 2840, which almost doubled to 5344 by 1860.

With the development of the water-power at Lewiston Falls, manufacturing corporations were chartered and organized. A first attempt to develop shoe manufacturing in the city began with the organization of the Minot Shoe Company in 1835. Jacob H. Roak became the owner in 1840 and began shoe manufacturing near Maine and Court Street in 1847. The industry was very primitive with the leather cut and then being "farmed out" to the community to be stitched by

workers at home. Gradually, machinery was introduced and by 1870 the factory system was generally adopted. Most of the shoe manufacturers were located at the water-power at Lewiston Falls, and between 1860 and 1870 the population within four miles of Goff's Corner doubled. In 1871 there were 21 shoe factories in Auburn which employed 2137 people and manufactured 2,367,000 pairs of shoes.

The Roak Block on Main Street was constructed in 1871-72. This building was owned by Jacob Roak and eight other partners. The building was constructed as a row house with each partner having a separate vertical section. Each section housed a shoe manufacturer. This was the largest structure of its type in Maine in the 1870s. In 1891 there were six shoe factories, employing almost 800 people located in the Roak Block. This building was used by the shoe industry until the 1950s. It has recently been rehabilitated and houses apartments and several small retail stores. It is listed on the National Register of Historic Places.

Lisbon

The town of Lisbon was part of the West Bowdoinham plantation. It was incorporated as the town of Thompsonburgh in 1799, but the name was changed to Lisbon in 1802. Lisbon consists of three villages, Lisbon, Lisbon Falls and Lisbon Center. Lumbering was the chief occupation of the first settlers. Between 1790 and 1800, at the confluence of the Little River and the Androscoggin in Lisbon Falls, there were six large saw mills in operation as well as a corn and grist mill and a carding mill. A clothing mill was on the Little River in 1806 which continued in business until 1835.

The water-power privilege at Lisbon Falls was developed in the mid 19th century. The Worumbo Manufacturing Company was organized in 1864 and produced all-wool beavers, a type of hat and woolen fabrics. Other mills on the privilege were the Androscoggin Water-power company which operated a saw mill and a grist mill, and the Lisbon Falls Fibre Company organized in 1889. The fibre company constructed a dam and pulp mill in 1890.

The Worumbo Manufacturing Company mill was constructed in 1864 and is still in operation using very similar technology as when it was organized. The mill is listed on the National Register of Historic Places.

Topsham

Topsham was first settled between 1717 and 1722. Settlement occurred very slowly however, due to Indian hostilities in the area. In 1746 there were 43 people in Topsham many of whom were killed by an Indian attack. With the cessation of the Indian wars the population increased at a moderate rate. When the town of Topsham was incorporated in 1764, the population was about 300.

During the late 18th and early 19th century the major industries in Topsham were shipping and lumbering. Topsham was also known for shipbuilding. There were at least three ships launched from Topsham between 1767 and 1772. By 1820 almost 1000 tons of shipping was being moved through Topsham and Brunswick. The Alfred White Shipyard in Topsham launched a 160 ton brig in 1842. In 1855 the steamboat, Victor, was launched from Topsham. This boat was only the second steamboat ever built on the Androscoggin.

The first saw mill in Topsham was built on the Cathance River at Cathance Falls in 1716 by the proprietors of the settlement. There were several dams constructed on the Androscoggin in Topsham between 1753 and 1770. The first mills on the river in Topsham were built on two of these dams in 1772. By 1784 there were at least four saw mills on the Androscoggin, two of which were located on the site of the Pejepscot Paper Company. These saw mills, each with four saws under one roof, were known as the "Great" mills. By 1877 only one saw mill remained.

Other early industries included several grist and flour mills, a sash and door manufactory, a fulling mill, a wool carding mill and a match factory. In 1872 the Howland Brothers established the Howland Patent Car Derrick shop. This was an invention of considerable importance for the railroad industry.

In 1868 the Topsham Paper Company was built on the site of the former "Great" mills. This was the first paper mill in Topsham. In 1874 the property was sold and the Bowdoin Paper Company was organized. In 1894-95 the Pejepscot Pulp Mill was constructed. With the buildings from the Bowdoin Paper Company and the pulp mill, a new plant was formed for the Pejepscot Paper Company organized in 1898. The company employed 200 people and produced 65 tons of paper per day. The company was the first mill in Maine to produce paper from wood pulp. The mill complex is now one of the best preserved industrial sites in Maine. The Pejepscot Paper Company

is listed on the National Register of Historic Places.

SOCIO-ECONOMIC RESOURCES

Population

The basin encompasses all or parts of 59 towns five plantations and two cities in Maine, and 11 towns, 14 unincorporated places, and one city in New Hampshire. The population of the basin, based on the 1980 Census, numbers 187,200, of which 166,700 are in Maine and 20,500 are in New Hampshire.

The distribution of the population, as defined in the 1980 Census, is 67 percent urban and 33 percent rural, with all of the urban population concentrated in two cities and portions of six towns in Maine and one city in New Hampshire. Urban areas and other places having populations in excess of 5,000 are listed in Table 11.

TABLE 11

POPULATION - ANDROSCOGGIN RIVER BASIN

MAJOR URBAN AREAS

Town and State	1980 Population
Lewiston, Maine	40,481
Auburn, Maine	23,128
Berlin, N.H.	13,084
Brunswick, Maine	18,170
Rumford, Maine	8,240

Manufacturing

Manufacturing is of great importance to the economy of the basin, with about two-thirds of the towns engaging in manufacturing to some extent. The largest of the manufacturing centers are located along the main stem, and provide employment to about 26,000 of the estimated 32,000 manufacturing workers in the basin. Over 65 percent of the 26,000 employees work in the manufacturing centers located in the lower reach of the river.

The more important manufacturing centers in the basin and their principal products are: Auburn and Lewiston with the greatest concentration of shoe and textile mills in the State, other products being electronic elements, sheet metal, printing, bricks, lumber products, baking and canned foods: Berlin - pulp, paper and allied products, athletic footwear, knit goods and foundries; Brunswick - canned food, shoes, brushes and lumber products; and Rumford - paper and paper

products.

Agriculture

About 20 percent of the basin is in farm land with much of that land devoted to wood lots. The suitability of land for agricultural crop purposes varies throughout the basin. The mountainous upper area in New Hampshire and Maine consists of relatively wide major valleys with many lakes and swamps, with the few part-time farms scattered through the southern fringe of the area. The central portion of the basin, a hilly plateau with hills generally rising to elevations of 1,000 to 2,000 feet above sea level, is predominantly dairy area. The lower section of the basin, with broadly rolling hills rising to elevations of 500 to 600 feet above mean sea level, and the Rangeley Lake area are well suited for all farm crops. Near the coast, truck farming on sandy soil near large centers of populations is the major agricultural activity. Many of the farms include dairy enterprises with the primary source of farm income from dairy products and poultry. Other farm income is from livestock, field crops, vegetables, fruits and nuts, horicultural specialities, and forest products.

Recreation

While manufacturing, lumbering, and retailing are the principal occupations throughout the basin, income from recreation is an important factor in the economy of the area. The scenic environment, numerous lakes, and cool climate attract great numbers of visitors during the summer months. The high quality of fishing and abundant wildlife account for considerable sportsman use during the spring and fall seasons.

Forestry

More than 80 percent of the land area of the basin is forested. It provides raw material for the wood-using industries in the valley and supports directly or indirectly about one-fourth of the population of the basin. Most of the forest land, except in mountainous areas, is of good quality, and produces commercially valuable species of timber such as spruce, fir, pine, beech and birch. Large holdings of forest lands are managed for sustained yields.

Transportation

The transportation pattern in the basin reflects the distribution of population. The more populous southern and central portions of the basin are served by a network of highways, while the sparsely populated northern area has fewer roads. The main highways are U.S. Nos. 1, 2, I-95 and 202 and State Route Nos. 4, 5, 16, 17, and 26, and the Maine Turnpike. Freight service is provided by the Maine Central Railroad, which serves the towns in the eastern portion of the basin, the Canadian National Railroad (Grand Trunk) which crosses the watershed from Portland, Maine, to Berlin, New Hampshire, and the Boston and Maine Railroad which connects Berlin with Whitefield, New Hampshire. Two commercial and one military airport and nine small airfields are located in or adjacent to the basin.

PROBLEM IDENTIFICATION

EXISTING PROBLEMS

General

For this study, the major floods of record (March 1936, March 1953, and March/April 1987) were analyzed to determine the hydrologic development of floods and the tributary contributions to flood peaks on the main stem. This analysis is essential to determine the flood potential of the basin and recognize the tributaries or subwatershed areas that offer the most potential for reduction of main steam flood levels. For the purposes of the hydrologic analysis, the basin was divided into 2 sections; the large upstream storage areas above Errol, and the unregulated river basin below Errol. The basin below Errol was further divided into reaches with the key index stations located at the USGS gaging stations at Gorham, Rumford, and Auburn. In addition, other key locations were identified at mouths of larger tributaries and at other points along the main stem. Streamflow and storage data from the USGS and Union Water Power Company were used for this analysis. Ungaged area hydrographs were developed using characteristically similar gaged watersheds and prorating the observed hydrographs by drainage area ratio. Flood hydrographs along the Androscoggin River were routed downstream with allowance made for travel time, characteristics of the river reach, amount of intervening flow, and relative timing of peak flows.

The 1936 and 1953 floods were previously studied using the methodology as detailed below. Results are shown graphically on plates 11 and 12. The 1987 flood was analyzed during this study and is shown on plate 13:

Effects of Upstream Storage

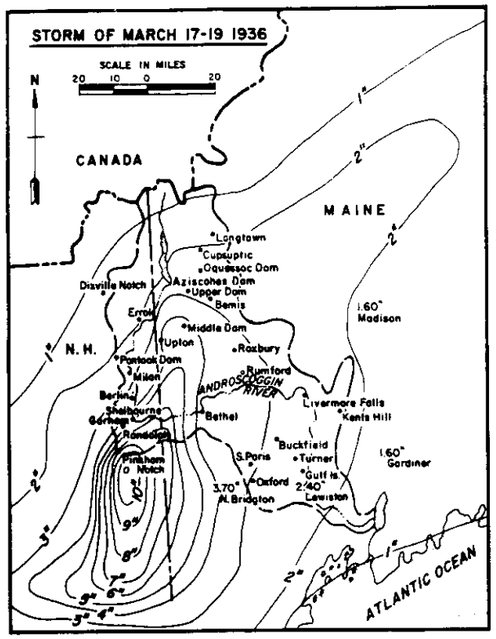
The Androscoggin River basin upstream of Errol Dam has approximately 660,500 acre-feet of storage (equivalent to 12 inches of runoff from the 1,045 square miles of contributing drainage area) in the Rangeley Lakes system. Flood runoff from this area is greatly modified by the large amounts of storage in the lakes. Average daily outflows from Rangeley, Mooselookmeguntic, Upper and Lower Richardson, Aziscohos, and Umbagog Lakes were obtained from the Union Water Power Company. Flood inflow hydrographs to these storage areas were computed using the reported average daily outflows and daily changes in lake storages in the continuity equation:

$$\text{INFLOW} = \text{OUTFLOW} + (\text{Change in}) \text{ STORAGE}$$

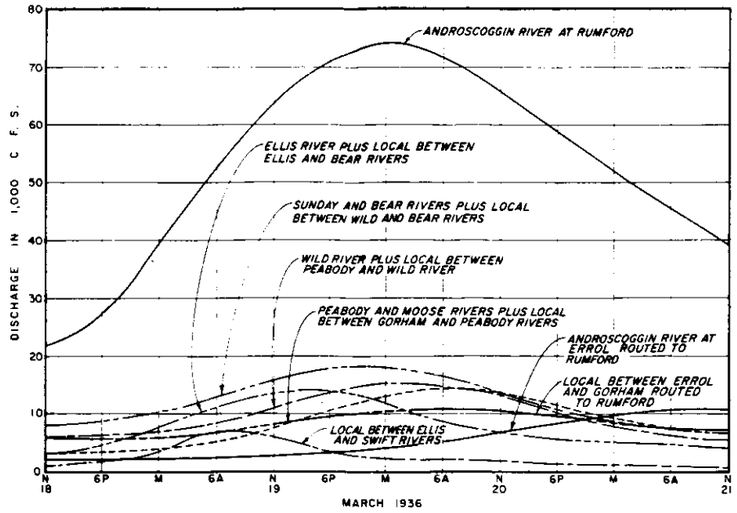
The resulting inflow hydrographs at the individual storages for the 1987 flood event are shown on plate 14. Because they are based on average daily outflow and change in reservoir storage, they are approximations only, with sketched hydrographs based on hydrologic engineering judgement.

Flood Routing

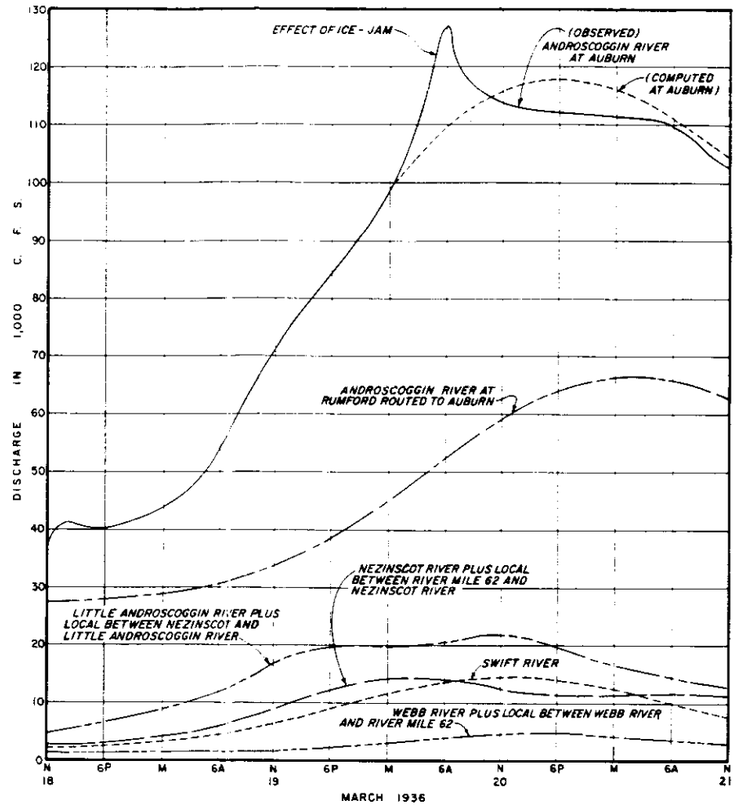
Flood hydrographs were routed downstream along the main stem of the Androscoggin from Errol to Rumford using the progressive average lag method of routing. For the reaches between Rumford and Auburn, a variable coefficient routing method was used (Table 11a. shows the routing coefficients used for each reach). The basin was divided into tributary and local subwatersheds for



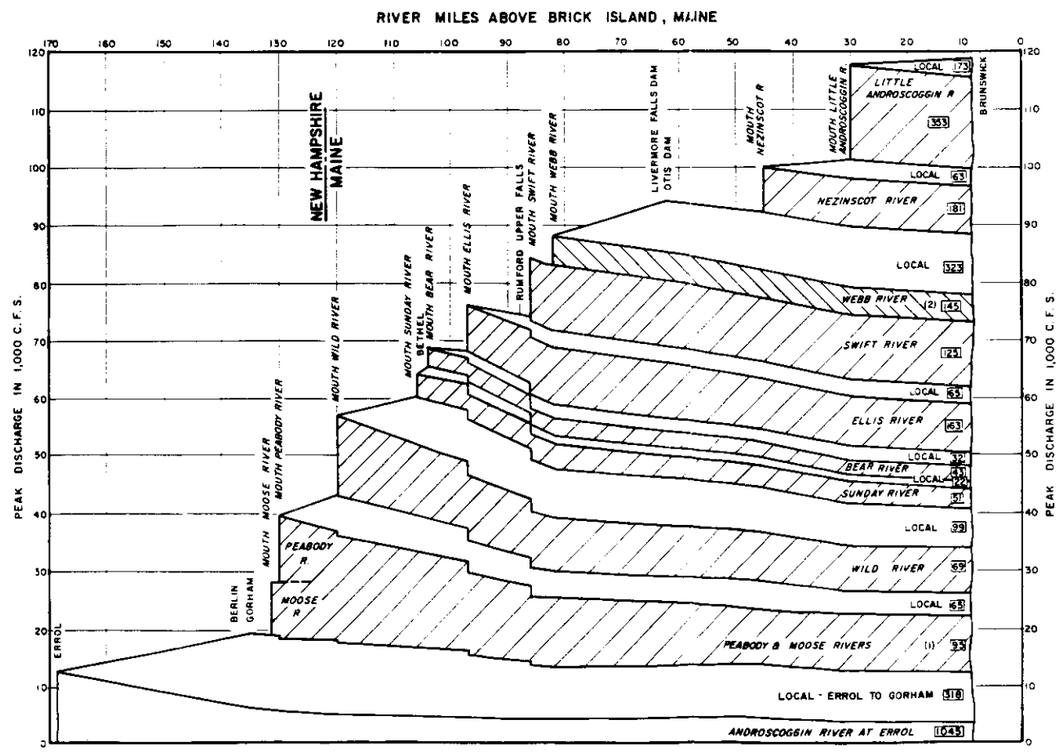
ISOHYETAL MAP



ANDROSCOGGIN RIVER AT RUMFORD



ANDROSCOGGIN RIVER AT AUBURN



PEAK DISCHARGE PROFILE AND TRIBUTARY CONTRIBUTIONS

NOTES:

(1) Includes 24 sq. mi. of Local Area.

(2) Includes 13 sq. mi. of Local Area.

LEGEND

[363] Drainage Area in sq. mi.

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS

DR. BY | TR. BY MWB | CK. BY

PROJECT ENGINEER

CHIEF, SECTION

SUBMITTED BY

CHIEF, PLANNING & REPTS BRANCH

ANDROSCOGGIN RIVER FLOOD CONTROL

FLOOD OF MARCH 1936

ANDROSCOGGIN RIVER MAINE & N.H.

APPROVED DATE

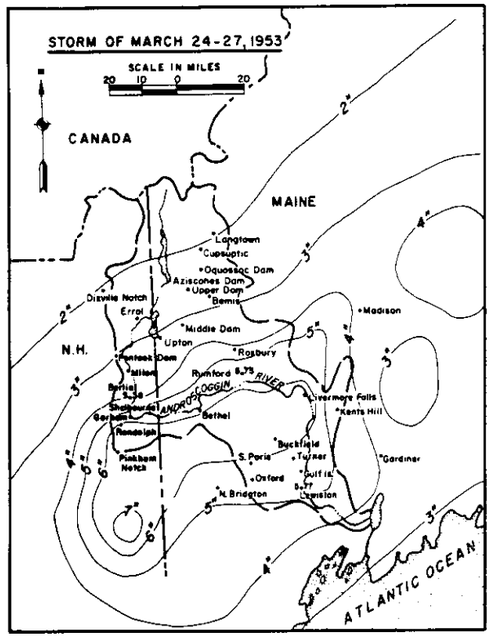
CHIEF ENGINEERING DIV.

SCALE

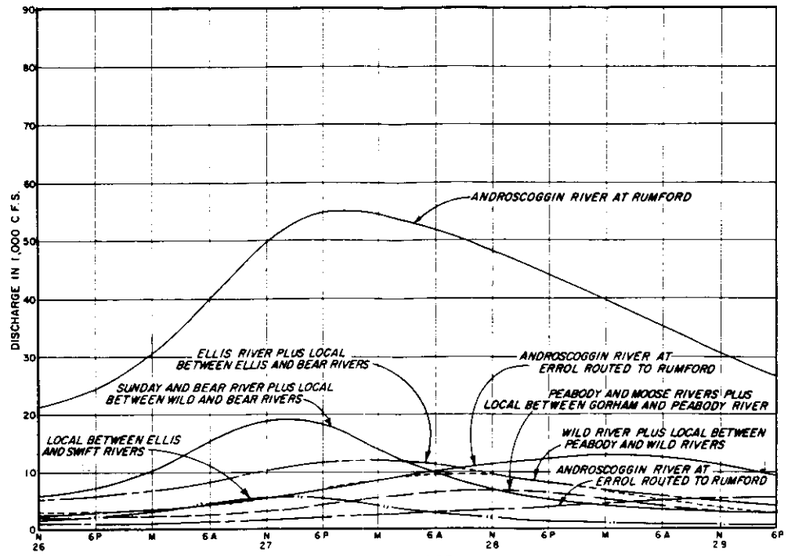
SPEC. NO. CIV. ENG.-18-016-

DRAWING NUMBER

SHEET

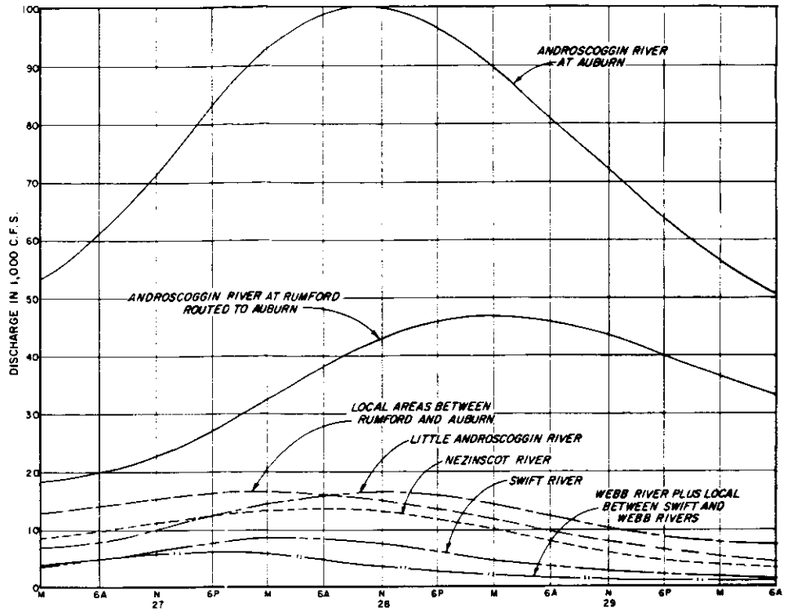


ISOHYETAL MAP



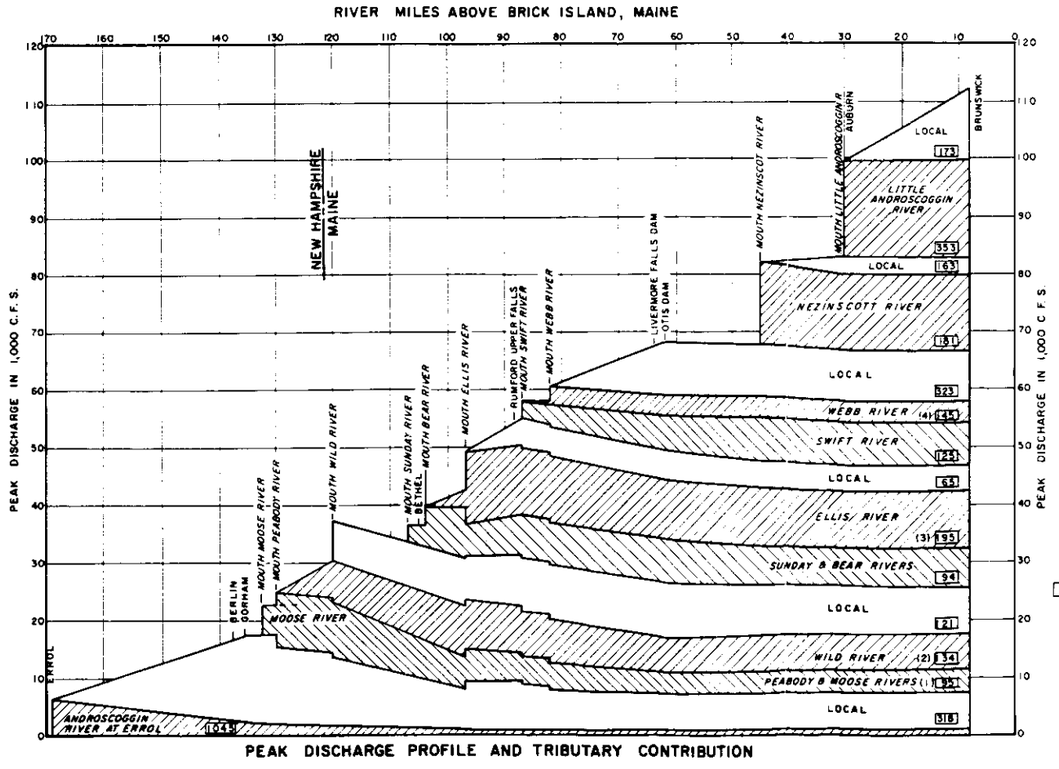
MARCH 1953

ANDROSCOGGIN RIVER AT RUMFORD



MARCH 1953

ANDROSCOGGIN RIVER AT AUBURN



PEAK DISCHARGE PROFILE AND TRIBUTARY CONTRIBUTION

LEGEND

1363 DRAINAGE AREA IN SQUARE MILES

NOTES:

(1) Includes 24 Square Miles of Local Area.
(2) Includes 65 Square Miles of Local Area.
(3) Includes 32 Square Miles of Local Area
(4) Includes 13 Square Miles of Local Area

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DR. BY | TR. BY G.M.D. | CK. BY

PROJECT ENGINEER

CHIEF, SECTION

SUBMITTED BY

CHIEF, PLANS & SPEC'S BRANCH

ANDROSCOGGIN RIVER FLOOD CONTROL

FLOOD OF MARCH 1953

ANDROSCOGGIN RIVER MAINE & N.H.

APPROVED DATE

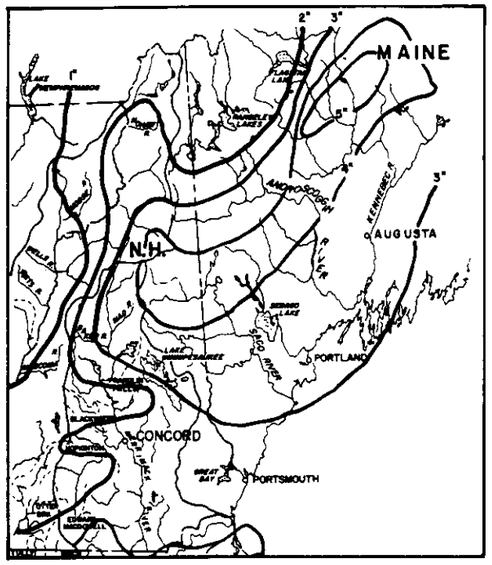
CHIEF ENGINEERING DIV.

SCALE | SPEC. NO. CIV. ENG.-53-016

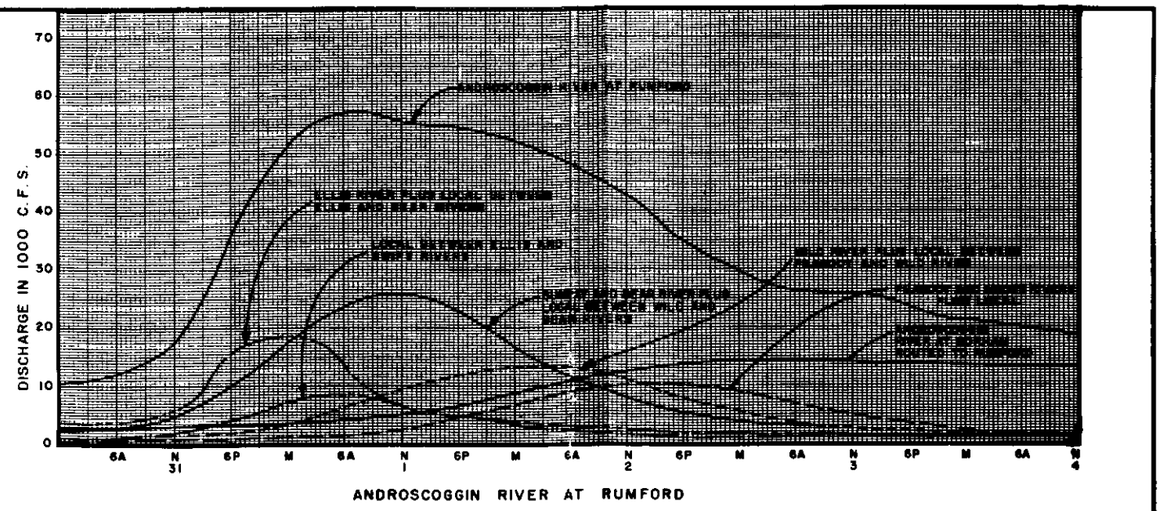
DRAWING NUMBER

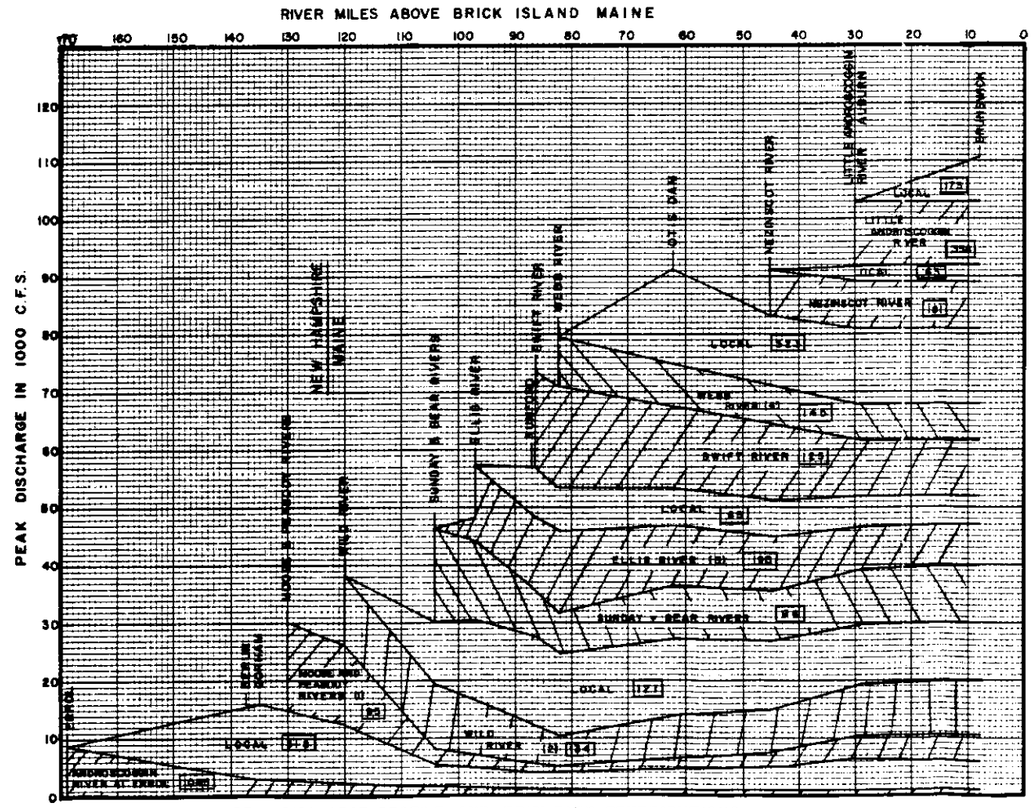
SHEET

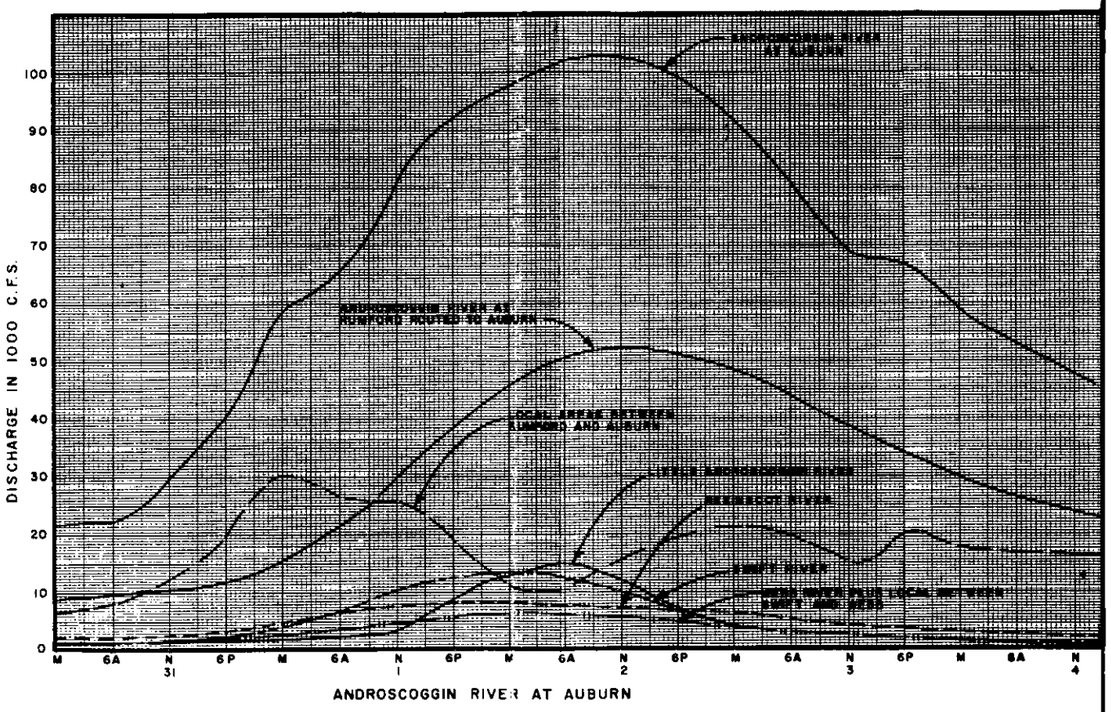
STORM OF 31 MARCH - 1 APRIL 1987



ISOHYETAL MAP







ANDROSCOGGIN RIVER AT AUBURN

LEGEND

[121] DRAINAGE AREA IN SQ. MI.

NOTES:

(1) INCLUDES 24 SQ. MI. OF LOCAL AREA
(2) " 65 " " " "
(3) " 32 " " " "
(4) INCLUDES 13 SQ. MI. OF LOCAL AREA

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

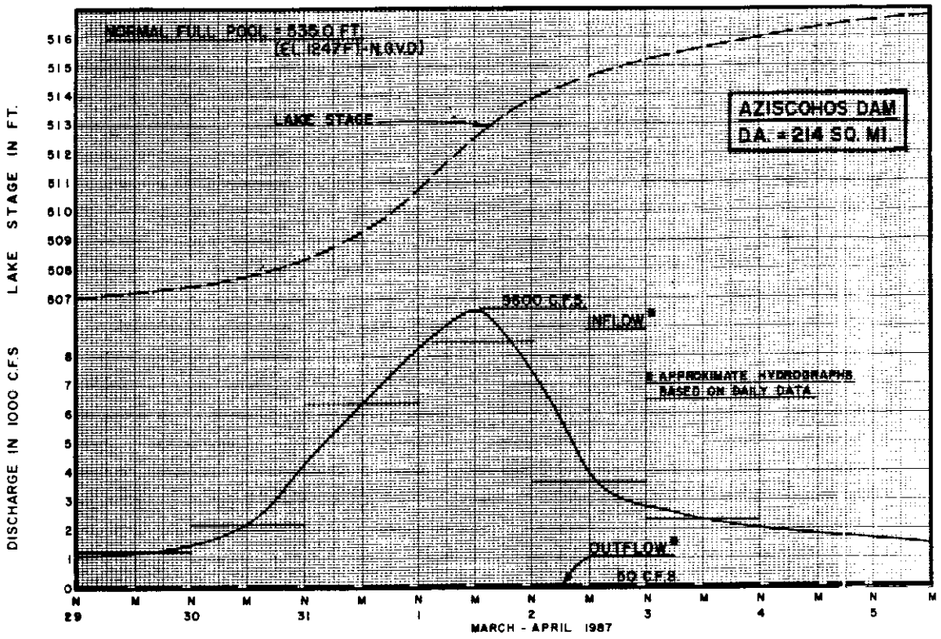
ANDROSCOGGIN RIVER BASIN

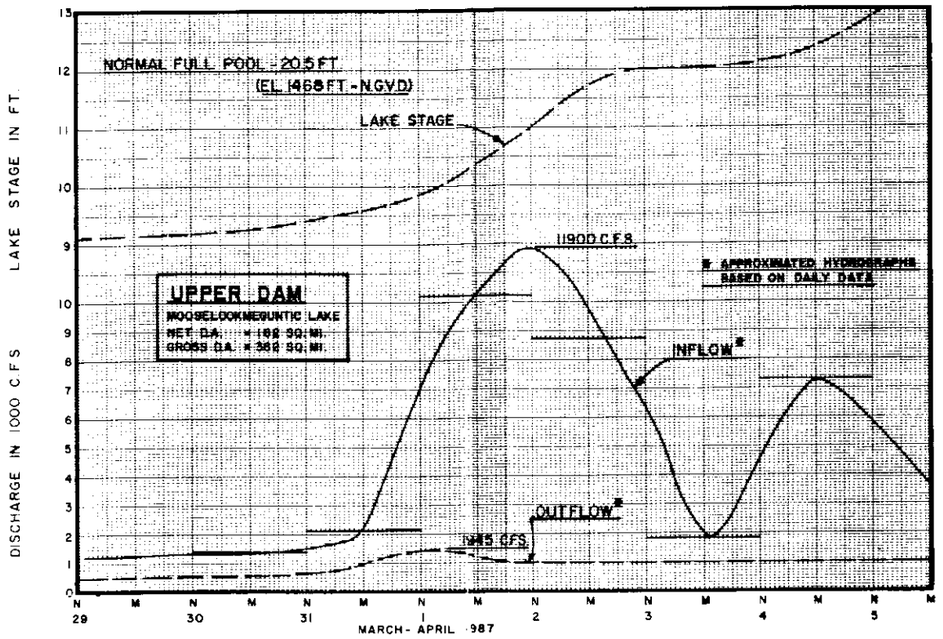
FLOOD OF

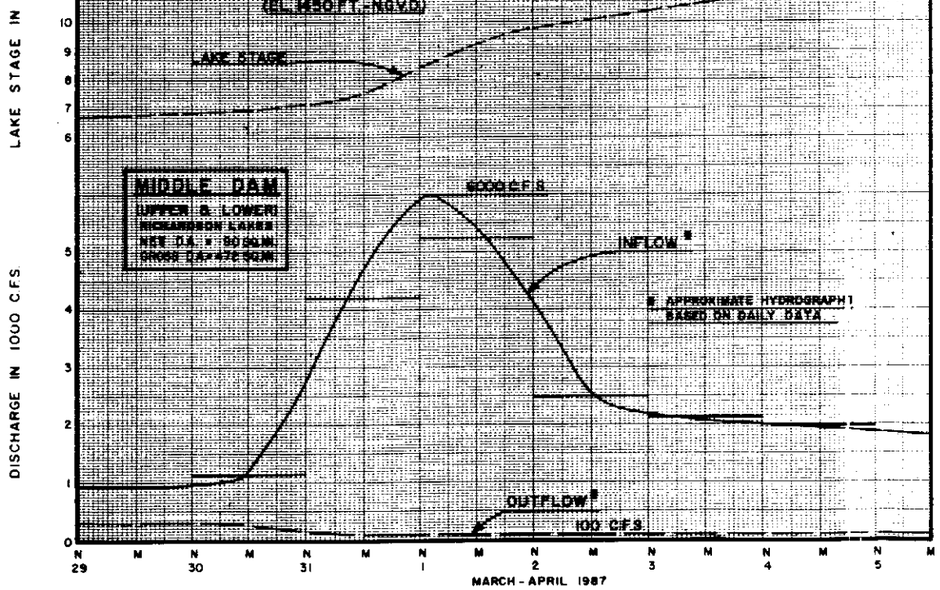
MARCH - APRIL 1987

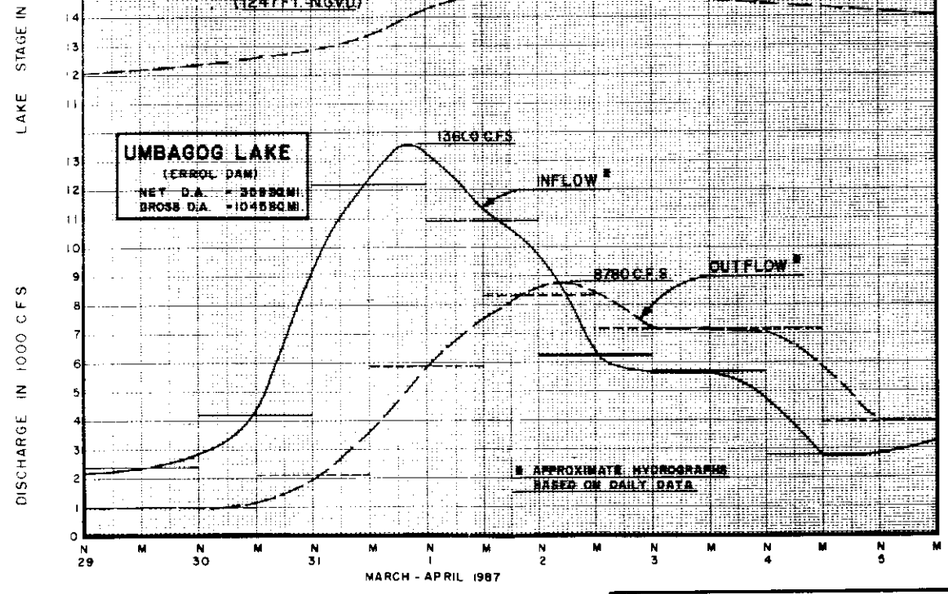
ANDROSCOGGIN RIVER — MAINE & N.H.

PLATE 13









DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM MASS

ANDROSCOGGIN RIVER BASIN — N.H. AND MAINE

MARCH–APRIL 1987 FLOOD ANALYSIS

UPPER BASIN STORAGE

HES — FEB. 1989

PLATE 14

TABLE 11a.

ANDROSCOGGIN RIVER BASIN
ROUTING COEFFICIENTS

ROUTING REACH NO.	REACH LIMITS RIVER MILE	DESCRIPTION	COEFFICIENTS (2) C1	C2	C3	C4	C5 (1)	AVG. (3) (IN NO. OF PERIODS)	LAG (3) (IN NO. OF PERIODS FROM MIDDLE OF AVG.)
1	135	USGS Gage Gorham	--	--	--	--	--	2	1/2
2	130	Mouth of Moose & Peabody Rivers	--	--	--	--	--	2	1/2
3	120	Mouth of Wild River	--	--	--	--	--	5	3
4	104	Mouth of Sunday & Bear Rivers	--	--	--	--	--	2	1/2
5	97	Mouth of Ellis River	--	--	--	--	--	3	1
6	87	USGS Gage, Rumford (Mouth of Swift River)	0	0.1	0.2	0.7	0	--	--
7	82	Mouth of Webb River	0.1	0.25	0.5	0.15	0	--	--
8	62	"Otis" Dam, Chisholm, ME	0.1	0.2	0.3	0.3	0.1	--	--
9	45	Mouth of Nezinscot River	--	--	--	--	--	3	1
10	29	USGS Gage, Auburn, ME (Mouth, Little Androscoggin River)							

NOTES:

1. Basic routing equation: $O_4 = C_1 I_1 + C_2 I_2 + C_3 I_3 + C_4 I_4 + C_5 I_5$.
2. Routing Coefficients are applicable for instantaneous flows expressed in CFS for 6-hour intervals of time.
3. Lag-Average coefficients are normally expressed as average/lag-"N" hour CFS.
   Example: 3/1 - six hour CFS denotes an average of three instantaneous 6 hour CFS and a LAG of one 6-hour period.

this analysis with the resulting watershed delineation as previously shown on Plate 2.

Routing coefficients were calculated initially by trial and error through reproduction of the 1936 and 1953 floods of record, and final selection was based on best-fit calibrationwith recorded flood hydrographs. Routed flood hydrographs for the 1936, 1953, and 1987 floods at Rumford and Auburn are shown on plates 11, 12, and 13 respectively.

Results

Peak discharge diagrams and tributary contributions for the 3 floods analyzed are also shown on plates 11, 12, and 13.

(1) Upstream of Errol. Because of the large amounts of storage above Errol, flood runoff from this area is greatly modified. Only during major floods is there any appreciable floodflow from this area. Although the drainage area of 1,045 square miles above Errol Dam represents almost 50 percent of the watershed above Rumford, this area contributes less than 5 percent to peak flows at Rumford. Further downstream at Auburn, this 1,045 square mile drainage area represents almost one-third of the total watershed, but contributes less than 3 percent to the peak flow.

(2) Errol to Gorham. The net drainage area between Errol and Gorham is 318 square miles and represents 23 percent of the total watershed at this point. Peak flows at Gorham tend to be generated by the local flow from this net area, with peak outflows from Errol Dam occurring a day or two later. This often results in a double peaked hydrograph at Gorham, with the second peak or outflow from storage generally being lower then the first. Runoff from this area contributes from 8 to 13 percent of flood peaks at Rumford and 6 to 7 percent at Auburn.

(3) Gorham to Rumford. The principal flood producing tributaries in this central portion of the basin drain the slopes of the White Mountains. They are; the Moose, Peabody, Wild, Sunday, Bear, Ellis, and Swift Rivers, and have a total drainage area between them of 643 square miles, or almost 20 percent of the total watershed area at Auburn. However, these tributaries contribute almost 40 percent to peak flows at Auburn. The contribution of the Ellis River is somewhat uncertain due to the fact that the lower portion of the river is very flat and has a large amount of natural storage. The main stem of the Androscoggin causes backwater flooding into this storage area and, therefore, retards flood flows from exiting the Ellis River. A gaging stationw as in operation from 1963 to 1982 on the Ellis River to aid in studying this phenomenon. Unfortunately, the gage has been discontinued and recorded Ellis River flow data for the 1987 flood is not available. The 1987 flood contribution from the Ellis was estimated by working backwards and subtracting out known flood hydrographs.

(4) Rumford to the Mouth. The Nezinscot and Little Androscoggin Rivers are the main flood contributing tributaries in the lower portion of the river basin. They drain approximately 24 percent of the net (downstream of Errol) drainage area at Auburn, and contribute about 20% to the peak flows. Their peaks tend to be synchronous with the peak of the main stem Androscoggin. The gage on the lower portion of the Little Androscoggin River at Auburn was discontinued in 1982. However, recorded data is available at an upstream gaging station. Flood hydrograph data at this location for the 1987 flood was determined using recorded data at the upstream gage on the Little Androscoggin, prorating by a drainage area ratio, and calibrating the peak timing based on the

timing of recorded flood hydrographs on the Little Androscoggin at Auburn for the 1936 and 1953 flood events.

Table 12 lists the component contributions to peak flood flows, in percent, at Gorham, Rumford, and Auburn for the 1936, 1953, and 1987 flood events.

FUTURE CONDITIONS

The Androscoggin River Basin is not presently heavily developed and large areas of the flood plain remain uninhabited. Preservation of the basin's natural storage capacities in the headwaters of the main stem and in most of its tributaries has played a major role in reducing flood stages. Pressure to develop the flood plain areas will decrease this natural storage capacity of the basin, thus, increasing future flood stages in the basin. Commercial and residential structures that currently experience flood damages will continue to experience periodic flood damages. To the extent that higher flood stages occur with time, additional properties may be impacted.

STATEMENT OF PROBLEMS AND OPPORTUNITIES

The authorizing resolution for the Androscoggin River Basin study provided the basis for identification of the problems and opportunities in the study area. Identified needs in the Androscoggin River Basin were based upon a preliminary assessment of current conditions and coordination with local, State and Federal agencies. The resulting statement of desired outputs for the study were used to guide the formulation of alternative plans, assessment of impacts, and evaluation of each plans response to the planning objective. Problem and opportunity statements are as follows:

a. Reduce future inundation damages, particularly in the 9 communities identified in this study, caused by flooding in the Androscoggin River and its tributaries.

b. Enhance, wherever possible, water quality for supply, irrigation, recreation, and aesthetic purposes in the Androscoggin River Basin.

c. Provide where possible, additional contributions to the regions water and related land recreational resources within the Androscoggin River Basin.

d. Assist in the preservation of fish and wildlife habitat and resources, and cultural and natural resources within the Androscoggin River Basin.

TABLE 12
ANDROSCOGGIN RIVER BASIN
COMPONENT CONTRIBUTIONS
TO
ANDROSCOGGIN RIVER FLOOD PEAKS

Location	Contributing Component	Drainage Area (sq mi)		Percent Contribution March 1936 (%)	March 1953	Peak Flow March/April 1987	
Average							
Gorham, NH	Androscoggin at Errol	1,045	76.7	28.8	13.0	16	19.3
	Local--Errol to Gorham	318	23.3	71.2	87.0	84	80.7
		1,363	100.0	100.0	100.0	100.0	100.0
Rumford, ME	Androscoggin at Errol	1,045	50.5	5.5	1.8	7.5*	13.7
	Local--Errol to Gorham	318	15.4	13.8	12.6		
	Moose & Peabody Rivers	95	4.6	17.4	8.2	3.0	9.6
	Wild & Local	134	6.4	20.4	12.9	15.0	16.1
	Sunday & Bear Rivers	94	4.6	9.8	14.7	21.0	15.2
	Local Areas	121	5.9	14.4	18.7	21.0	18.0
	Ellis & Local	195	9.5	15.7	21.2	19.5	18.8
	Local Area	65	3.1	3.0	9.8	13.0	8.6
	Total	2,067	100.0	100.0	100.0	100.0	100.0
Auburn, ME	Androscoggin at Errol	1,045	32.2	3.1	6.5	6.1*	8.1
	Local--Errol to Gorham	318	9.7	7.7	1.0		
	Moose & Peabody Rivers	95	2.9	8.3	4.1	3.9	5.5
	Wild & Local	134	4.1	10.0	6.2	9.2	8.5
	Sunday & Bear	94	2.9	5.2	6.6	9.3	7.0
	Local Areas	121	3.7	7.5	8.3	10.0	8.6
	Ellis & Local	195	6.0	9.4	10.1	7.3	9.0
	Local	65	2.0	2.4	4.4	5.0	3.9
	Swift River	125	3.8	9.7	7.5	9.6	8.9
	Webb River	145	4.5	4.0	3.7	5.7	4.5
	Local Areas	323	9.9	8.8	8.9	12.9	10.2
	Nezinscot River	181	5.6	7.0	13.5	7.8	9.4
	Local Area	63	1.9	3.0	2.7	2.5	2.7
	Little Androscoggin R.	353	10.8	13.9	16.6	10.7	13.7
	Total	3,257	100.0	100.0	100.0	100.0	100.0

* Total to Gorham, DA = 1,363 square miles

PLAN FORMULATION

PLANNING CONSTRAINTS

Planning constraints are conditions imposed upon the planning process that limit the range of feasible alternatives available to the planner. These constraints may consist of legal, social, and environmental factors of such importance that violating them would compromise the entire planning effort.

One such policy constraint on the planning process results from the 1983 Maine Rivers Act approved June 17, 1983. This Act provides special protection for various reaches of rivers, because their existing state provides unparalleled natural and recreational value, and irreplaceable social/ economic benefits to the people. This Act prohibits the construction of new dams on these rivers and stream segments without the specific authorization of the Legislature.

The Megalloway River from the New Hampshire state line upstream to Lake Azischolos is a protected stream.

Environmental Considerations During Formulation

a. Reregulation. Reregulation to increase flood storage capabilities would involve one or more of the following: increasing annual lake drawdowns to provide additional storage; surcharging the reservoirs or increasing the height of water control structures to provide additional storage; and/or changing reservoir refill/drawdown sequencing to provide additional storage capacity during peak runoff events.

The Rangeley Lakes are currently managed to store runoff and snowmelt during the spring months for gradual release during the summer and fall to provide uniform flow conditions in the mainstem Androscoggin River for downstream power and industrial water users. The mainstem dams also supply hydropower. Incidental benefits from the current operational regime include flood control for the valley below Errol and augmented flow conditions for whitewater boating and fishing during the natural low flow period.

Water level fluctuation in the Rangeley Lakes is presently a major factor affecting fish and wildlife productivity in the Rangeley Lakes and Mainstem reservoirs. Impacts from increasing the magnitude of annual water level fluctuations would include the following:

1. Increasing the drawdown could affect fish passage into spawning and refuge tributaries during low water conditions. As lake levels recede, tributary flow may become spread out over broad alluvial deposits (since water flows over the path of least resistance, flow in rills is more likely) or pass over waterfalls at stream mouths. Fish attempting to move upstream could be subjected to shallow water depths, impassable falls, higher temperatures, and/or predation. This is a critical issue since the salmonid and smelt fisheries are supported almost exclusively by natural production in lake tributaries. Access to cold water refuge habitat in lake tributaries is also critical for salmonids in Aziscohos Lake where water quality may become stressful by the end of the summer. Specific stream surveys during low water periods would be necessary to quantify the extent of this potential problem at each reservoir.

2. Additional lake drawdown could affect the aquatic food base for fish by reducing the area of productive littoral zone available for invertebrate reducing the area of productive littoral zone available for invertebrate food production depending on hydrography of the lake bottom. Insects and other aquatic invertebrates such as freshwater clams and mussels may be adversely affected by increased littoral zone exposure.

3. Increasing the magnitude of lake level fluctuations could exacerbate conditions that presently affect lake trout spawning in the Richardson Lakes. While not a problem at this time, because lake trout spawning would increase competition with existing fish populations, future management opportunities for natural lake trout production may be adversely affected.

4. Reductions in lake levels could affect water quality by changing stratification characteristics. Changes in water quality parameters such as temperature and dissolved oxygen could affect downstream riverine fisheries as well as reservoir fish resources.

5. Changes in the reservoir fill schedule could affect instream flow releases below the dams. Negotiations over instream flow releases will be underway at Aziscohos Dam and Middle Dam as part of the FERC licensing process. Instream Flow Incremental Methodology flow studies have been conducted at both projects, and will be the basis for specific flow recommendations. Any changes in the lake flow releases will have to be made within the framework of the instream flow levels eventually adopted as license conditions for these projects.

The high level of regulation existing in the Androscoggin Basin lakes means that extensive coordination will be necessary to ensure that any additional regulation for flood control is workable within the framework of the existing water management plans. Possibilities for low flow augmentation exist because of poor water quality conditions. The cold water fisheries in the lower Androscoggin River are described as borderline by Maine DMR. Any improvement in water quality would have positive effects on the fishery. Conversely, any degradation of water quality could have potentially significant negative effects. Further upstream in the river in New Hampshire high flows are considered a problem limiting spawning in the Androscoggin River. Studies have suggested that decreased flows would increase wetted useable area and fishing access. This suggests that some positive environmental effects could be achieved through reregulation but that a workable plan would be difficult to define because of the numerous competing interests.

6. Waterfowl and loon nesting/brooding activities could be affected by increased water level fluctuations although waterfowl nesting is limited in all but Umbagog Lake because of existing water level fluctuations. Surcharging the reservoirs during the spring runoff period could flood either newly established nests or traditional nesting sites. Permanently raising reservoir levels would also flood traditional nesting sites. New potential nesting sites may be reduced or increased depending on surround- ing topography and vegetation. Increasing reservoir drawdown during the spring and early summer months would decrease loon production by making their nest sites inaccessible. Waterfowl production may be similarly affected. Brook habitat would be impacted by reduced littoral productivity and nearshore cover availability.

7. Reduced lake water levels could have adverse consequences for emergent wetland and submergent aquatic vegetation in the Rangeley Lakes. This could reduce available habitat for fish

and wildlife, such as furbearers and waterfowl, dependent on this vegetation. Effects from wetland plant losses would extend beyond those animals dependent on these plants for food and cover. The loss of vertebrate and invertebrate prey organisms associated with aquatic plant communities could affect the entire food web.

8. Permanent water level increases would destroy or change surrounding upland vegetation. Permanent increases in lake water levels could flood cedar swamp deer yards or kill live nest trees in heron rookeries. The island rookery on Aziscohos Lake may be particularly vulnerable to flooding.

9. Lake level changes in Umbagog Lake could affect the unique floating bog communities there, including Floating Island, a National Natural Landmark administered by the Nation Park Service.

b. New Flood Control Reservoirs

1. The primary impacts would be the permanent loss of habitat from the construction of dams, access roads, and associated structures, and changes in habitat in the storage area. Clearing the storage area would result in the alteration of existing habitats including the highly valued riparian zone vegetation, surrounding forests, and depending on the site, streamside wetlands. Streamside habitats generally have high wildlife value because of the increased diversity of habitat where two or more habitat types come together. More open habitat would be associated with a poolless reservoir. If a pool is associated with the dam the habitat would change to open water. This change would result in the elimination of riverine habitat as well as surrounding upland habitats. If the pool water level is stable, shoreline wetlands may form.

2. With the changes in habitat associated with dam construction there would be a change in the associated wildlife. Overall, the construction would be expected to have detrimental impacts to wildlife and fisheries. The impacts to wildlife would affect year-round and seasonal users of the habitat as well as those species which use the riparian corridors as migration routes.

3. Fishery habitat values would change, and possibly increase as a result of low flow augmentation on tributary streams. However, existing fishery resources in the impact zone would generally be negatively affected by new flood control reservoirs. Among the direct aquatic habitat impacts would be the loss of cover, shade, and terrestrial food inputs from the removal of streamside vegetation in the impoundment zone. Substrate suitability for spawning and food production could be reduced as a result of sediment deposition behind the dam. Additional sediment sources may develop from the loss of vegetative cover and periodic flooding of the impoundment area. Increased sediment levels can adversely affect fish eggs, fish gills, and can reduce habitat quality by filling in pools and smothering productive riffles. If a permanent pool is created riverine coldwater fish habitat would most likely change to warmwater habitat.

4. Aquatic habitat downstream of the dams would change. The sediment load inflows would be deposited upstream of the dams where current velocity and turbulence decrease. As a result, the downstream portions of streams would become armored, that is, the channel bed would be covered with a layer of course gravel, cobble, and boulders. This could affect the suitability of the substrate for spawning for the coldwater and warmwater fish species residing in the streams. That sediment collected behind the dam could be flushed downstream during flood water releases

increasing tailwater turbidity. Changes in downstream aquatic communities and water quality can also occur as impoundment organisms and chemical constituents and low dissolved oxygen waters are flushed downstream during release of flood flows.

ALTERNATIVES CONSIDERED

To prevent or reduce flooding and associated damages, three types of protection were studied; structural, nonstructural, and automated flood warning systems. Automated flood warning systems, although nonstructural, were considered a separate category in this study. Structural and nonstructural measures differ in that structural measures affect the flood waters while nonstructural measures affect activities in the floodplain.

Channel improvements were not investigated along the Androscoggin River because the river has a relatively flat slope and depths of flooding are quite high (10 to 20 feet). Also, this river has a wide floodplain area that generally spans the valley cross section. It is felt that required channel improvements would be quite extensive and for those areas having the highest damage potential, channel improvements do not appear to be economically feasible.

Structural

Investigation of flood control reservoirs was limited to a review of the sites and designs evaluated in the 1967 Survey Report of the Androscoggin basin.

Investigation of local protection projects was accomplished by applying a screening process to the damage centers, and costing out any projects that survived the screening. A review of previously considered local protection projects was also accomplished.

Nonstructural

Two methods of nonstructural floodproofing were investigated. These methods are detailed in "Flood-proofing Regulations", Document No. EP-1165-2-314, U.S. Army Corps of Engineers, June 1972. These methods are:

1. Raise the structure and build-up the existing foundation walls to an elevation above the 100-year flood elevation.

2. Install closures for openings which will provide seals, thus dry flood-proofing the structures.

Automated Flood Warning System

An automated flood warning system consists of a series of remotely-located precipitation and/or stream flow gages that report to a computer. The computer gives information on predicted peak flood stage and the time to the peak stage. This information, through the application of a preparedness plan, can be translated into what would be expected to occur at individual communities in the Androscoggin River Basin. Flood warning is not a solution to flooding; it can help reduce damages and potentially save lives.

EVALUATION OF ALTERNATIVES

The purpose of this investigation is to develop and document the information necessary to determine if there is Federal interest in a further detailed investigations. Only cost-effective alternatives where the annual benefits provided by a project equal or exceed the annual cost of constructing the project are eligible for Federal participation. Since project feasibility is highly sensitive to hydrologic and economic analysis, a considerable amount of the study effort was dedicated to developing adequate detail in these areas. The analyses performed are documented and discussed in the following sections.

Benefit Estimation Methodology

Benefits were estimated for the different types of improvement plans by use of the following methods:

a. Structural: Reservoirs

Annual losses as developed in the current study were compared with those developed in the 1967 Survey Report.

b. Structural: Dikes

Annual losses prevented under existing conditions were calculated up to the specific level of protection (elevation) plus 50 percent of the freeboard range.

c. Nonstructural

Raising of First Floor - Annual losses to each structure were compared without the plan (first floor at existing elevation) and with the plan (first floor raised to one foot above the 100-year flood elevation). Benefits are the difference in total annual losses.

Closures - Annual losses were estimated for each building only for those damage categories that closures would prevent. For example, contents and structure were included, but non-physical losses and grounds were not. Benefits were calculated as reduced annual losses up to the level of protection. All closure plans were evaluated at the 100-year level of protection.

d. Flood Damage Survey

A flood damage survey was performed in the 9 areas during August to October 1988. Flood related losses were estimated for each floodprone structure and site, beginning at the elevation at which discernable losses and damages are first incurred up to the flood elevation of a rare and infrequent (500 year) event. The reference point at each structure was the first floor elevation. In addition to the NED flood damage survey effort, a local architect-engineer firm was contracted with to perform a nonstructural investigation for the 9 areas. As part of this contract, ground and first floor elevations were obtained for all structures in the 100-year floodplain. These elevations provided an additional level of confidence in the estimates of annual losses and benefits. The NED damage evaluator conducted interviews with knowledgeable people concerning flood losses to

commercial, industrial and public activities. For residential properties, use of sampling, typical loss profiles by type of house and minimal interviewing were employed. Both physical and non-physical losses were estimated. The cost of emergency services were obtained where possible. Damages to the transportation, communication and utility systems were also obtained for the towns, the State of Maine Dept. of Transportation and the Central Maine Power Co.

Recurring Losses

Recurring losses are those potential flood related losses which are expected to occur at various stages of flooding under present day development conditions. As the final output of the flood damage survey process, recurring losses are expressed as an array of dollar losses, in one foot increments, from the start of damage to the elevation of a rare and infrequent (500 year) event. Total recurring losses for selected events in the damage centers of the cities and towns under investigation are displayed in Table 13.

TABLE 13
RECURRING LOSSES

Recurring Losses for Selected Events

Damage Center	10 Year	50 Year	100 Year	500 Year
Rumford	$144,200	$1,227,500	$1,622,000	$2,015,200
Mexico	8,500	383,600	748,700	3,914,600
Peru/Dixfield	75,500	307,600	387,500	601,900
Canton	48,600	193,000	247,300	736,700
Lewiston	0	567,200	1,006,400	2,991,500
Auburn	25,000	318,800	780,800	3,992,200
Lisbon	46,100	119,300	147,800	518,200
Topsham	0	0	54,400	163,000
TOTAL:	$347,900	$3,117,000	$4,994,900	$14,933,300

Annual Losses

Annual losses are the integration and summation of two sets of data at each damage location. Recurring losses for each flood elevation (event) are multiplied by the annual percent chance of occurrence that each specific flood elevation (event) will be reached. The effectiveness of each alternative flood reduction plan is measured by the extent to which it reduces average annual losses. Annual losses in the damage centers of the 8 cities and towns are displayed in Table 14.

TABLE 14
ANNUAL LOSSES

Damage Center	Annual Losses
Rumford	$ 98,800
Mexico	$35,400
Peru/Dixfield	31,100
Canton	20,300
Lewiston	43,100
Auburn	38,900
Lisbon	18,900
Topsham	1,500
TOTAL:	$288,000

Improvement Plans

Both structural and nonstructural plans were formulated to reduce flood related losses in the basin. The structural plans involve local protection projects consisting of walls and/or dikes in selected communities. The nonstructural plans address: (i) raising the first floors of selected residential structures, (ii) installation of closures over openings in residential and commercial structures and (iii) an automated flood warning system.

The following paragraphs discuss the reservoir sites which were evaluated in the Corps' 1967 Survey Report. Characteristics of the dams, as well as the results of the 1967 economics are also discussed.

Flood Control Reservoirs

Pontook - The Pontook project consisted of a dam and reservoir, along with a re-regulating dam and reservoir located on the Androscoggin River approximately 12 miles upstream of Berlin, New Hampshire. The Pontook dam would have been a multipurpose power, flood control and recreation project, operated in conjunction with the storages in the Rangeley Lakes system. Total gross storage capacity at the project would have been 238,000 acre-feet. In the spring, a minimum of 98,400 acre-feet of storage would have been provided by Pontook for flood control, equivalent to 10.9 inches of runoff from its net drainage area of 170 square miles. The Rangley Lake system is operated to maintain a flow of 1,550 cfs at Berlin, New Hampshire. This operation results in the seasonal drawdown of the storages, generally beginning in June, and on average, resulting in about 185,000 acre-feet of storage available each spring. The lakes are then maintained drawndown with the 1,550 cfs requirement being provided by releases from Errol dam and runoff of the unregulated downstream tributaries. The resulting 185,000 acre-feet of incidental flood control storage in Rangley Lakes, together with the 98,400 acre-feet of flood control storage in Pontook, would result in about 284,000 acre-feet of total storage available. This storage is equivalent to about 4.4 inches of runoff over the 1,215 square mile drainage area.

Pontook dam would have had a maximum height of 106 feet, with top of dam at elevation 1,230 feet NGVD and an ogee weir spillway at elevation 1,180 feet NGVD. Full pool would have had a surface area of 7,470 acres at elevation 1,220 feet NGVD. With this project in operation, average

stage reduction (based on 1987 discharges) at Auburn for a significant flood event would have been about 0.9 feet.

With power development at Pontook at a low load factor, a second dam would have been needed approximately 6.5 miles downstream to re-regulate the peak turbine discharges to usable flows for downstream power plants. This dam would have been 53 feet high (elevation 1,136 feet NGVD), with full pool at elevation 1,121 feet NGVD and a 16,300 acre-feet capacity.

Although this project was originally economically justified, it was never authorized due to public opposition in environmental areas.

Ellis Dam and Reservoir - The Ellis dam and reservoir project would have been locted on the Ellis Riverin Rumford, Maine, approximately one mile upstream of its confluence with the Androscoggin River. This site was studied for flood control alone, flood control and recreation, and flood control, recreation, and power. The project would have consisted of a rolled earth dam with a maximum height ranging between 56 feet to 65 feet (elevation 671 to elevation 680 feet NGVD) depending on the chosen project purpose, and a chute spillway between elevation 642 to elevation 660 feet NGVD. A total of 90,000 acre-feet of flood control storage, equivalent to 8 inches of runoff from the drainage area of 164 square miles, would have been available with any of the 3 project scenarios. Average stage reduction at Auburn would have been about 1.0 foot with this project in operation.

As mentioned previously, flood flows along the Androscoggin tend to cause water to flow upstream at the mouth of the Ellis River and into natural storage areas. Insufficient information was available to analyze this phenomena, which was a concern with this project. This project was dropped from further study due to the above concern, but more importantly, the lack of economic justification.

Roxbury Project - This single-purpose only flood control project would have been located on the Swift River in Roxbury, Maine, approximately 11 miles above the mouth. The dam would have been 112 feet high (elevation 830 feet NGVD) and 2,000 feet long, with a spillway at elevation 810 feet NGVD. Approximately 36,300 acre-feet would have been impounded for flood control storage, equivalent to 8 1/2 inches of runoff from the 80 square mile drainage area. Average stage reduction of approximately 0.8 foot would have occurred downstream in Auburn. The project was not economically justified.

Hale Project - The Hale project site would have been located on the Swift River, approximately 2 miles above the mouth in Mexico, Maine. Two alternatives were looked at; one with flood control only, and the second, flood control, power, and recreation.

For the multipurpose project, a 255 foot high dam would have been constructed to elevation 784 feet NGVD, with a spillway at elevation 763 feet NGVD. Drainage area at the project site is 111 square miles. Total storage would have been 332,000 acre-feet, with 47,400 acre-feet allotted to flood control and 96,600 acre-feet for power. An average of about 1.2 feet of stage reduction could have been realized down-stream in Auburn. A re-regulating dam would have been needed approximately one mile downstream, with a maximum height of 52 feet (elevation 500 feet), spillway crest at elevation 486 feet, and a 40-acre pool. Benefit/cost ratios were close to one;

however, the project was not studied further, primarily because of resistance to its environmental impacts.

Re-analysis of Pontook Flood Control Reservoir

Of the four major flood control reservoir sites evaluated in the 1967 Androscoggin Study, only the Pontook site in Dummer, N.H. showed a favorable BCR. It should be noted that the BCR was marginal (1.1), and the project derived much of its favorable economics from a hydroelectric component, whose benefits were computed from a much more liberal kilowatt hour market price than is allowed today. In the final analysis, the project was not built due to a rising concern about its adverse environmental impacts.

As an update on the economic viability of the project, the following calculations were performed:

1.	1967 Cost Data:	
	a. Original Project Costs: separable single-purpose flood control project cost	$ 7.3M
	b. Annual Operating Cost:	1M
	c. Flood Damage reduction annual benefits:	$239,000
2.	1988 Cost Data	
	a. ENR Capital Cost Index	4.27
	b. Projected Pontook (original flood control design) First Cost:	$31.4M
	c. Current Damage Reduction Benefits (Price Update Factor = 3.88)	$927,000
3.	Current BCR	
	Amortization Rate of 8 7/8%	
	Annual Benefits =	$ 927,000
	Annual Cost =	$2,823,000
	Benefit/Cost Ratio =	0.3 to 1

It was further noted in the 1967 study that a recurrence of the 1936 flood (of record) would have caused $13.7M (1967 dollars) of damages in the basin. In the current study, a 500-year event would result in basin-wide damages of $14.9M (1988 dollars). It is clear, in evaluating this data, that the "protectable" flood damages in the basin have greatly decreased in real dollars in the last twenty years. Speculation on the cases of this phenomonon include: damage and non-replacement of floodplain structures by floods, fire, abandonment, etc.; and, provisions of local zoning in response to the National Flood Insurance Program preventing new, damageable, floodplain occupancy.

In any event, the one flood control reservoir project in the basin that was marginally (economically) viable in 1967, is overwhelmingly infeasible in the current analysis.

Local Protection Projects

The feasibility of providing localized structural projects to reduce flood losses was evaluated using several criteria. First, the nature and extent of damage sustained during the 1987 flood was documented by extensive field survey, interviews, and photographs of impacted structures. Of particular importance was the distribution of damage sites along the river.

Secondly, a minimum cost dike was formulated by the following calculations:

CALCULATION OF MINIMUM COST
DIKE FOR LPP SCREENING PROCESS

1. Assume an average dike height of four feet (one foot of protection at the 100-year flood stage, plus 3 feet of freeboard).

Cost per linear foot of Dike (Ref: Cost of Dike Curve)	$300/Ft.

2. Overhead For:

Engineering & Design Study and Administration - 28%	$ 84/Ft.

3. Contingency @ 25% $75/Ft.

Total Dike Cost	459/Ft

Then, utilizing this unit cost of $459/Foot, a maximum length dike was determined which could sustain $100,000 worth of annual benefits, and yield a 1.0 to 1 BCR as follows:

CALCULATION OF MAXIMUM DIKE LENGTH
SUSTAINABLE BY BENEFITS:

1. Assume: $100,000 Annual Benefits (100 year protection)
   1.0 Minimum Benefit-Cost Ratio
   8 7/8% Amortization Rate.

2. Minimum Annualized Dike Cost to Yield 1.0 BCR = $100,000

3. Equivalent First Cost @ 8 7/8%
   Amortization = $1,127,000

4. Maximum Dike Length to Sustain
   $100,000 Benefits @ Minimum Unit Dike Cost ($459/Foot)
   $= \frac{1,127,000}{459} = 2450$ Feet

Finally, the screening analysis was completed by determining a maximum length of such a dike which could be supported in each of the damage centers. This maximum length was then compared to the distribution of damageable structures along the river. The following table summarizes the results:

TABLE 16
SCREENING RESULTS FOR LPPs (Dikes)

Damage Area (Community)	Benefits From 100-year Dike	Max. Length of Dike Sustained By Damages Prevented	Length of Dike Required to Protect Damage Area*
Rumford (Virginia Section)	$84,000	2060 Feet	2000 Feet
Mexico	18,200	450	1500
Peru/Dixfield	27,900	680	3500**
Canton	17,000	420	4000
Auburn	20,300	500	3000
Lewiston	26,500	650	4000
Lisbon	17,000	420	1000
Topsham	400	--	1000

*Note that consideration was given to protecting subsets of the damageable properties with proportionally shorter dikes. This did not prove to be viable at any of the damage centers.

**Protection needed on both sides of river.

The only LPP which warranted further attention, based on this screening, was that for the Rumford (Virginia), ME area.

Evaluation of the Rumford LPP

A cluster of residential and commercial structures exists in the floodplain along the west bank of the Androscoggin River, in the Virginia Section of Rumford, ME. Recurring losses for these buildings are $1.2 and 1.6 million for the 50 and 100 year floods respectively.

Flood losses could be prevented through the construction of an earthen dike, running principally north-south, and located between State Route 2 and the river (see figure 18). The dike would tie in to high ground near the Rumford Road bridge at the north end, extend some 2,000 feet southerly, and cross Rt. 2 at its southern limit, to tie back to high ground. A stoplog design would close Rt. 2 during a flood event.

Dikes to provide both 50 and 100 year protection to the Virginia area were costed as shown in Table 16a. First costs were $1167K and $1392K respectively, yielding corresponding BCRs of .73 to 1 and .68 to 1.

Although there would be a significant reduction in average annual losses, the construction costs outweighted expected benefits, and the project was dropped from further consideration.

TABLE 16a.
COST SUMMARY RUMFORD LPP (DIKE)

	50 YR PROTECTION	100 YR PROTECTION
1 Height		
Avg. Height = Flood Stage[1] - Avg. Grd[2]	5 FT	7 FT
2. In-Place Costs		
Stone (@ $35/CY)	$ 80K	$102K
Gravel (@ $30/CY)	231	250
Fill (@ $10/CY)	67	112
Clear ($.05/SF)	5	6
Strip ($2/SY)	20	24
Excavate ($12/CY)	63	63
Land Aquist ($1000/Acre)	5	
Stop Logs (Rt 2) ($576/SF)	69	115
Inter Drg[3] (L.S.)	200	200
TOTAL	$740K	$877K
3. Calculate Annualized Costs		
Contingency (25%)	185	219
E&D, S&A (27%)[4]	242	296
Project Total	$1167K	$1392K
Annualized (8 7/8%)	$104K	124K
4. Benefits	$ 76K	$ 84K
5. BCR	.73 to 1.	.68 to 1.

FOOTNOTES TO
RUMFORD DIKE COST CALCULATIONS

1. Flood Stages in Damage Area:
   S100 = 623 Ft. NGVD
   S 50 = 621 Ft. NGVD

2. Average Ground Elevation:
   619 Ft. NGVD
   (Also Rt. 2 Elevation)

3. Interior Drainage:
   20 CFS with minor Ponding
   inside dike area
   Cost per CFS
   = $10,000
   Total Cost for Pumps = 20 x $10K = $200K.

4. Total Engineering, Design, Supervision & Administration Costs @ Project Cost = $10M
   = 27%

Reconsideration of Previous LPP Analysis

As a further evaluation, two prior evaluations of LPPs on the main stem Androscoggin, done under the Corps' Section 205 Authority, were re-evaluated.

In 1976, a reconnaissance scope investigation was done in Auburn. The site under evaluation was some 30 acres in the downtown area, south of North Bridge, north of the R.R. Bridge, and immediately abutting the Androscoggin. That evaluation found that a dike to protect the area would cost $1.5 million, vs. preventable damages less than $200,000 (recurring 1936 flood). The report concluded that the benefits were insufficient to warrant a Corps project. Using inflationary capital cost factors, and a current benefit figure of $20,300 annually, it is clear that the project continues to be unjustified.

A similar analysis was done in Lewiston in 1971, under the same authority. One of the alternatives evaluated at that time was a concrete floodwall. Cost (in 1971 dollars) was estimated at $2.2 million, and annual benefits were $13,200. Once again, insufficient payback is indicated.

In conclusion, all evaluated local protection projects failed to yield a favorable return.

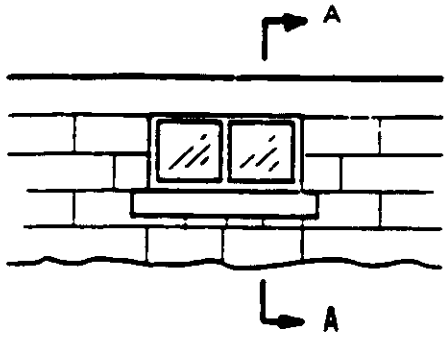
Nonstructural Alternatives

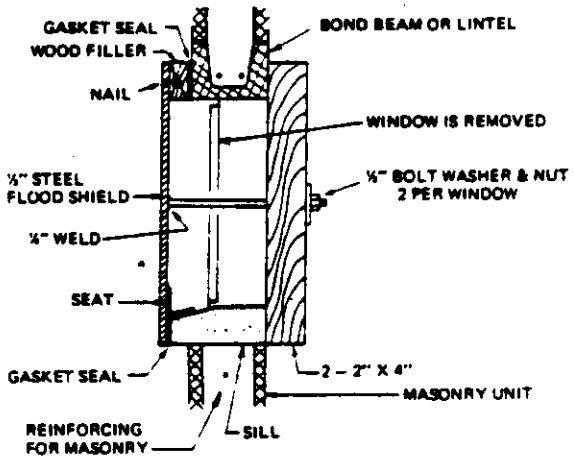
A field survey was conducted in order to determine the number of occupied buildings within each community flooded by the 100-year (1 percent chance of occurrence) storm event; and to obtain first floor elevations and low corner elevations for these buildings. The field data collected was then grouped according to usage (residential, commercial, etc.) and to the type of building materials (masonry and wood). Floodproofing estimates were then developed according to the structure types.

Two methods of floodproofing were investigated. These methods are detailed in "Flood-Proofing Regulations, Document No. EP-1165-2-314, U.S. Army Corps of Engineers, June 1972". These methods are:

1) Raise the structure and build-up the existing foundation walls to an elevation above the regulatory flood datum. Existing structures with basements would be required to relocate any utilities, and the basement would then be filled in with suitable material.

2) Install closures for openings which will provide essentially dry barriers or seals. This





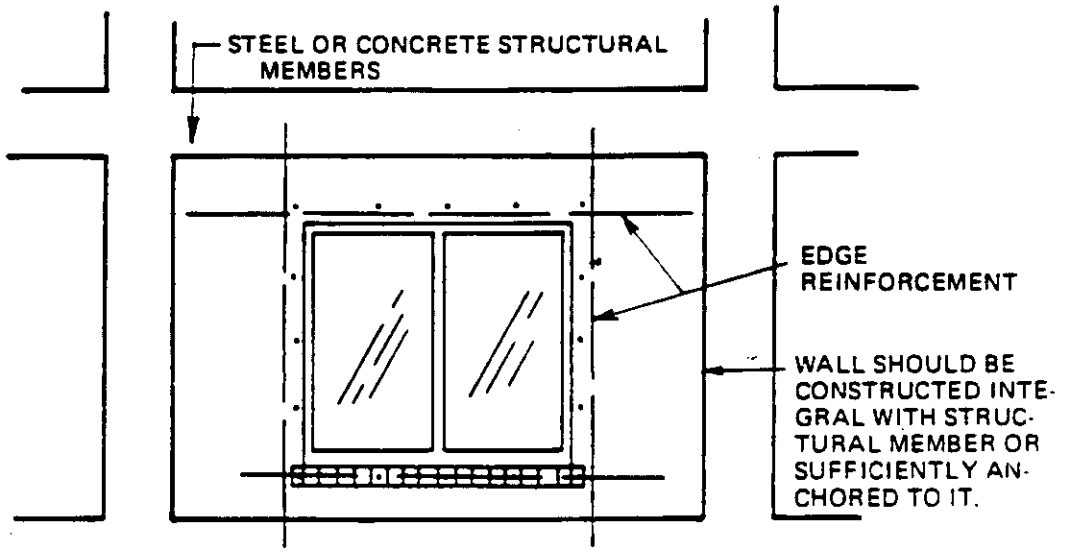
SECTION A-A

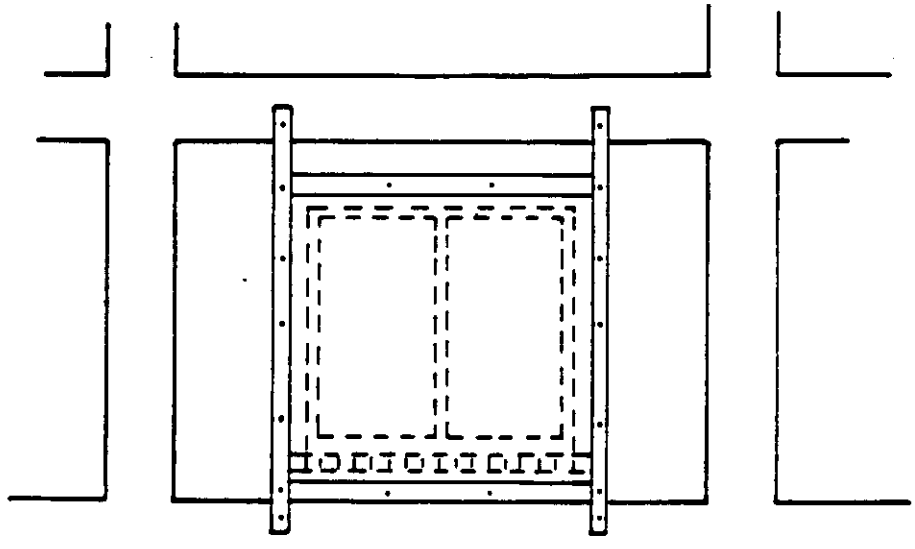
CLOSURE PANEL FOR BASEMENT WINDOW
FOR SMALL WINDOWS AND SHALLOW DEPTH OF FLOODING

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MA.

TYPICAL CLOSURE PANEL

BASEMENT WINDOWS





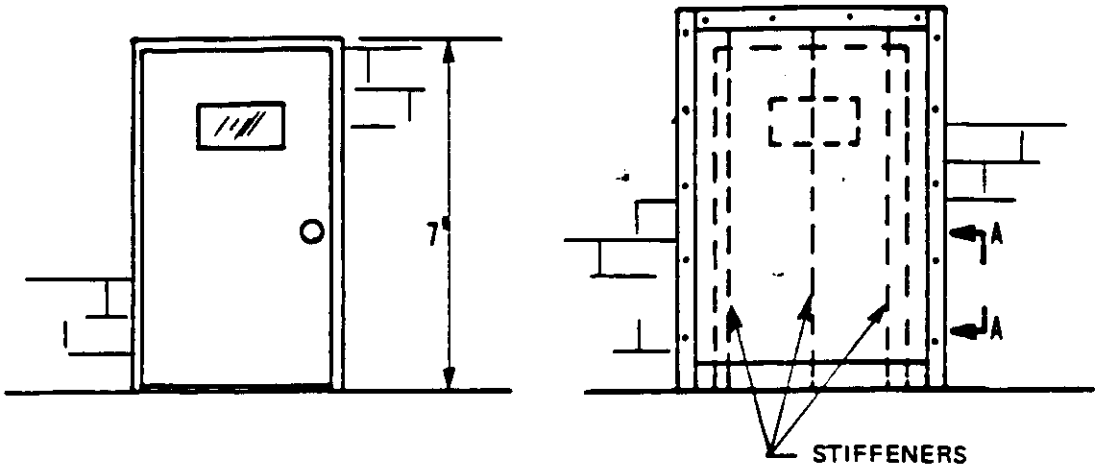
REINFORCING FOR BOND BEAMS AND VERTICAL STEEL MAY BE REDUCED IF FORCES ARE TRANSMITTED TO STRUCTURAL MEMBERS BY THE FLOOD SHIELD FRAME AS SHOWN ABOVE.

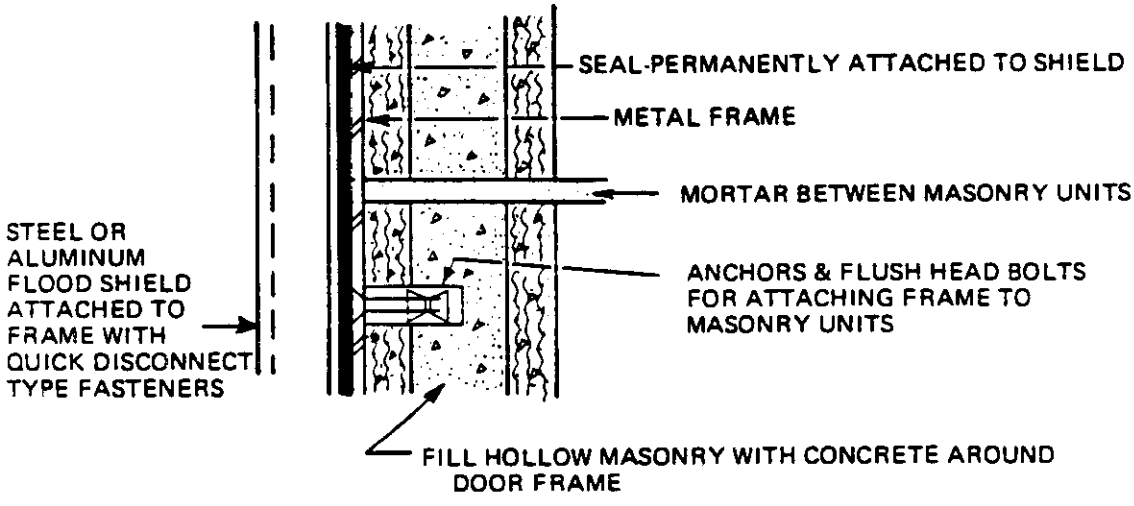
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MA.

BOND BEAMS
VERTICAL REINFORCEMENT

LARGE OPENINGS

TYPICAL DOOR





SECTION A–A

ALL CELLS AROUND OPENINGS IN HOLLOW MASONRY CONSTRUCTION SHOULD BE FILLED WITH CONCRETE. LARGE OPENINGS SHOULD HAVE BOND BEAMS, VERTICAL REINFORCEMENT, AND METAL FRAMES AROUND OPENING.

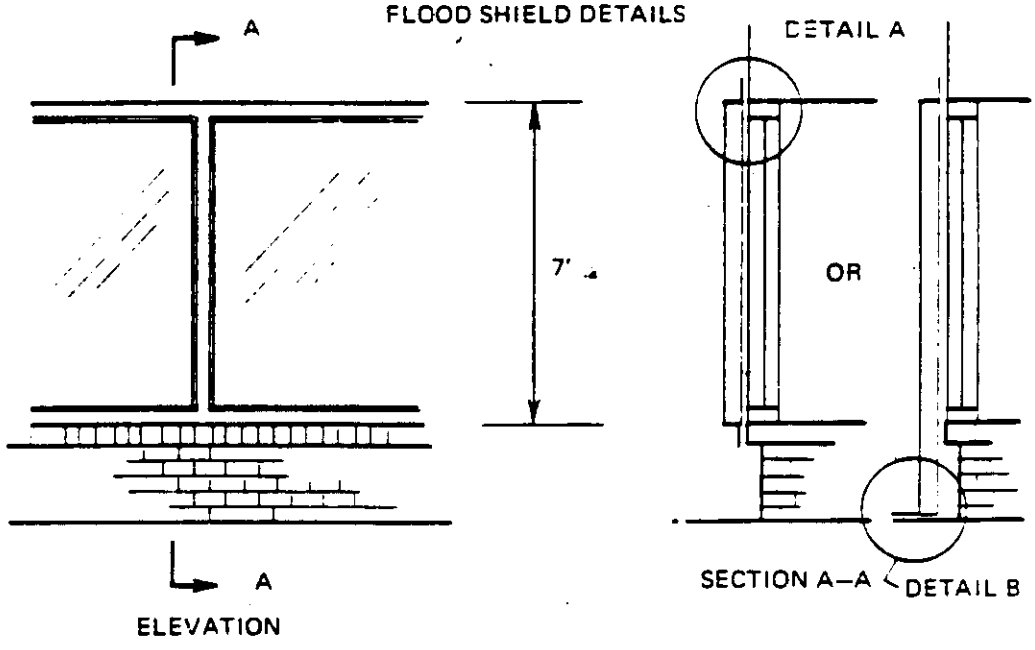
MORTAR JOINTS THAT LIE WITHIN FLOOD SHIELD SHOULD BE STRUCK FLUSH WITH THE MASONRY UNITS SO THERE WILL BE A BETTER SEAL.

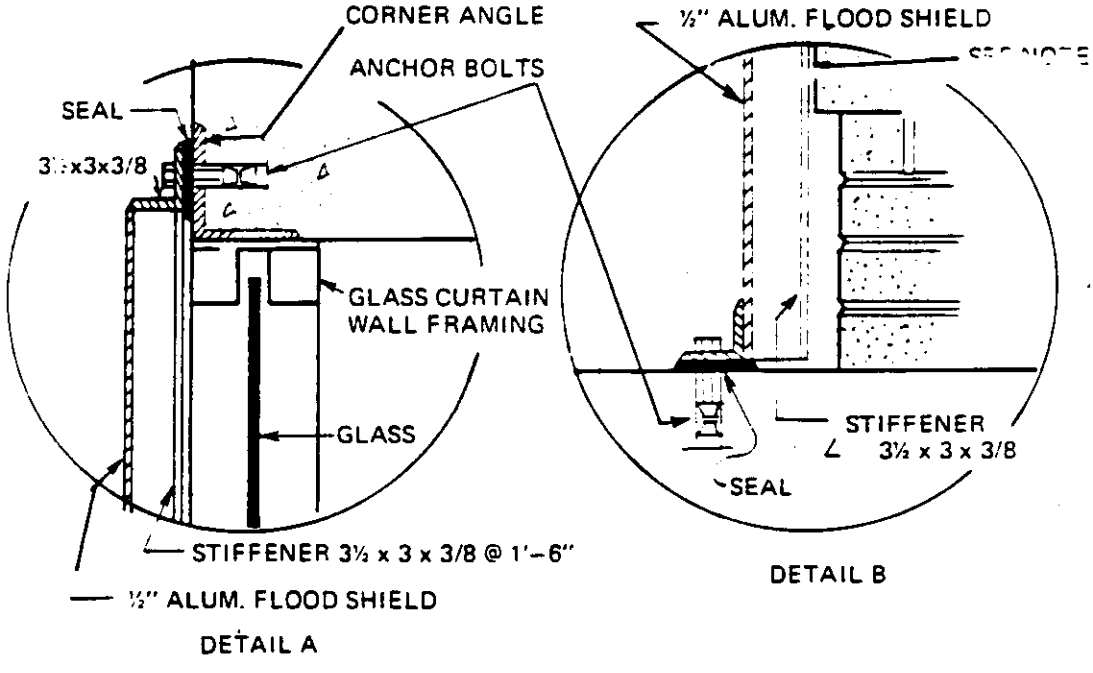
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MA.

TYPICAL DOOR CLOSURE PANEL

PLATE 17c

DISPLAY WINDOW
FLOOD SHIELD DETAILS





NOTE:
SUPPORT IS ASSUMED AT THIS LOCATION. WHERE SUPPORT IS NOT AVAILABLE, INCREASE SIZE OR NUMBER OF STIFFENERS AND PROVIDE SUPPORT AT BOTTOM.
MEMBERS ARE SIZED FOR WATER LEVEL AT TOP OF DISPLAY WINDOW.

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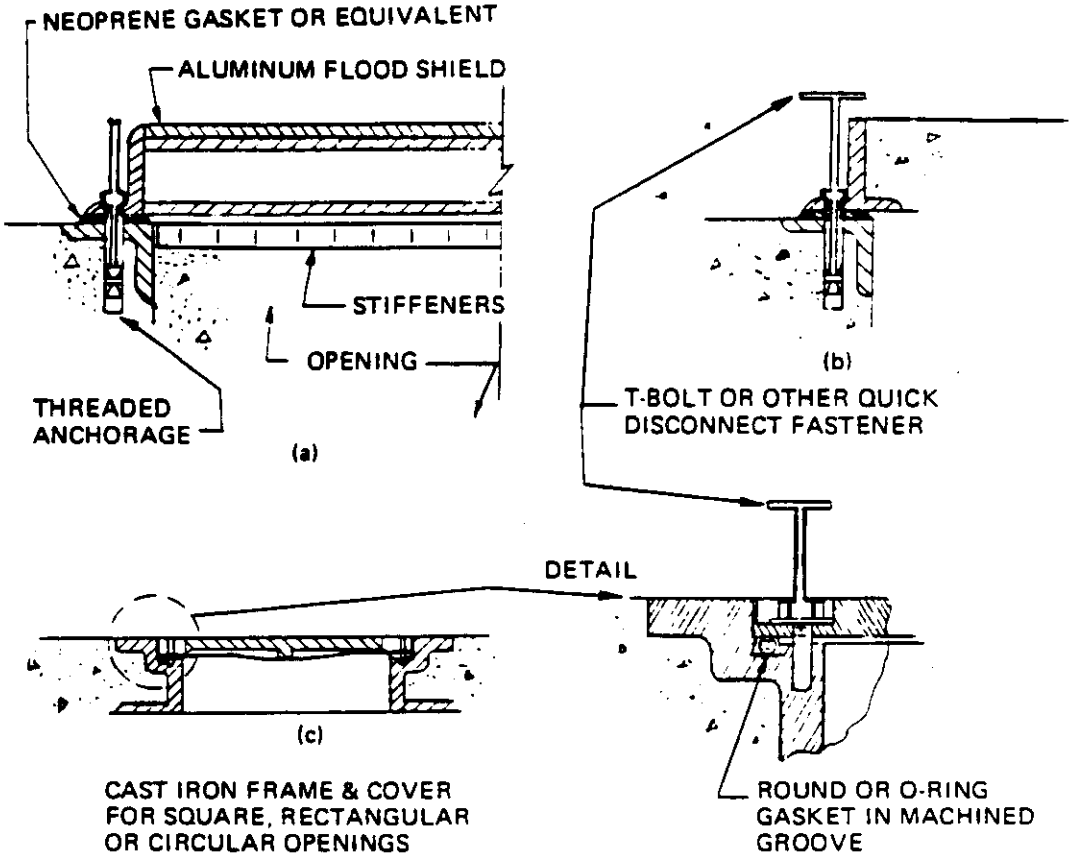
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MA.

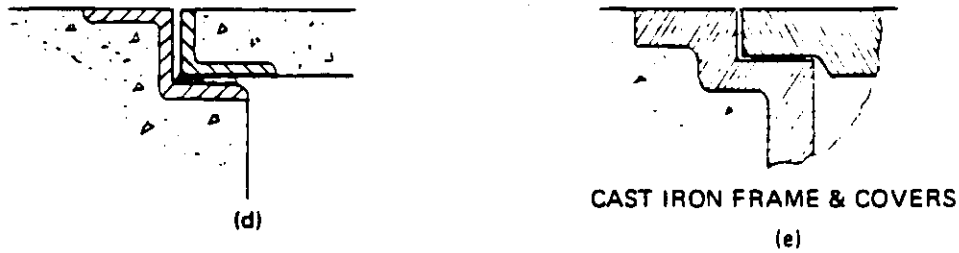
TYPICAL DISPLAY WINDOW

CLOSURE PANEL

PLATE 17d



COVERS FASTENED TO FRAME



GRAVITY TYPE COVERS
(HELD IN PLACE BY WEIGHT ALONE)

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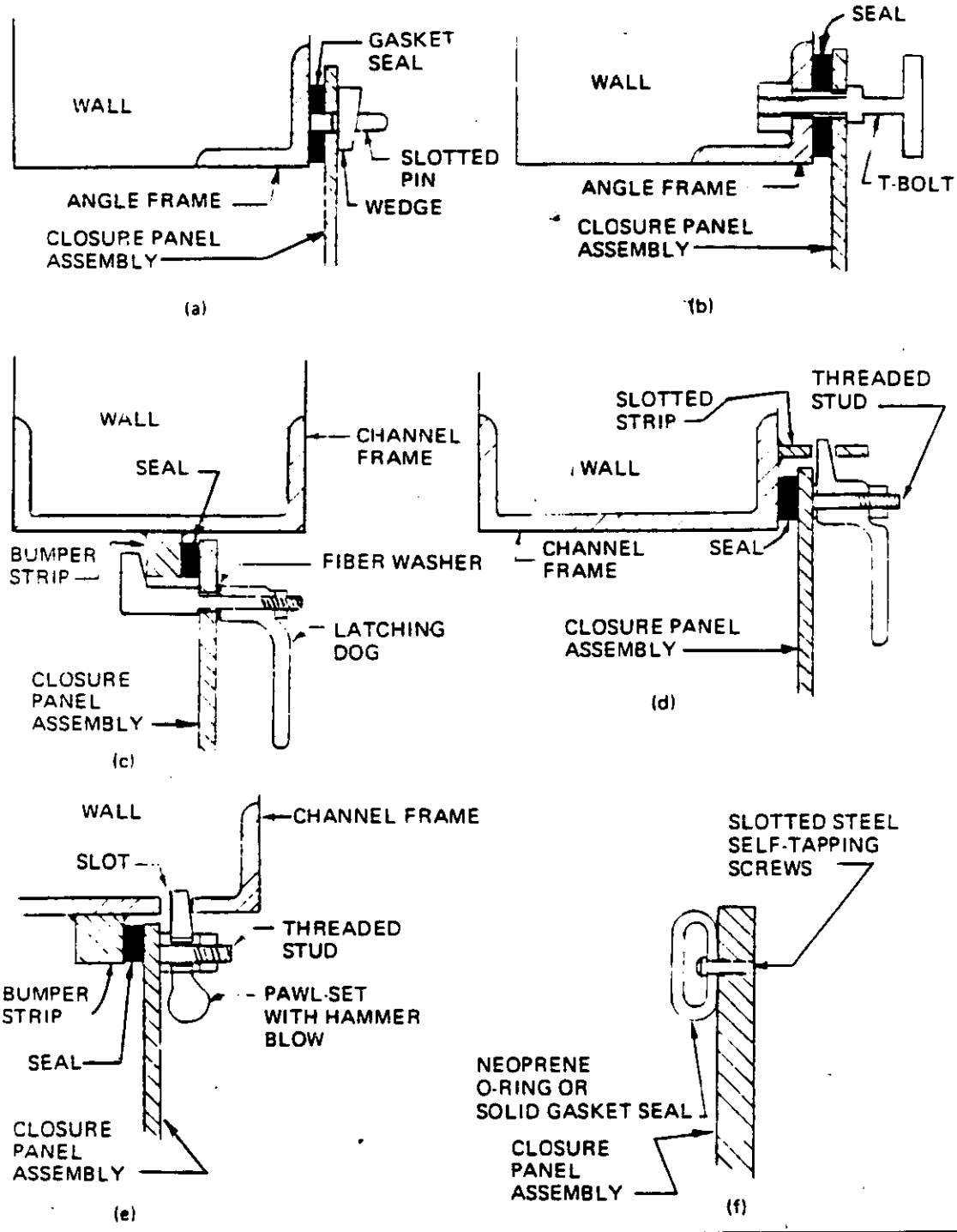
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MA.

TYPICAL CLOSURE

HORIZONTAL OPENINGS



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MA.

CLOSURE PANEL ASSEMBLY

FASTENING METHODS

PLATE 17f

is a Type 2 Closure and would consist of aluminum flood shields with stiffeners, watertight gaskets and structural frames permanently anchored to each building. Closures for windows and doors will be similar to those shown on Plates 17a. thru f.

The estimate for each community is also based on the types of structures within the flood hazard area. These classifications generally consist of residential, commercial, or industrial usage; which is detailed further to include the structures building material, ie. wood or masonry, which was determined by visual identification. Since the field survey was not required to determine the existence, size or structural capacity of basement walls, all the floodproofing methods described herein are based on the premise that if a basement exists, it will withstand any hydrostatic pressure and prevent the passage of water into the interior space. The floodproofing estimate for residential construction is divided into three categories: wood construction, 1-1/2 stories or less; wood construction, 2 stories or more; and masonry construction. Wood construction of 1-1/2 stories or less will allow the structure to be jacked with the foundation walls built up to a level above the regulatory flood datum. Wood construction of 2 stories or more does not allow this method, generally due to the structure height as well as the larger square footage for each level. The masonry residential buildings encountered in the twelve communities are predominately larger apartment buildings, but the estimate has been modified to reflect smaller buildings when they were encountered.

The estimate for the commercial/storefront buildings is divided into two types of construction - masonry and wood. The masonry construction consists of brick, cement block and several structures constructed from granite. Buildings which did not fall into the above categories were classified as public works and assembly buildings which were primarily masonry construction. A summary of nonstructural costs according to building type are shown in Table 19.

Prior to implementing any of the floodproofing methods described herein, a detailed investigation to determine the exact construction method, design strength and present condition of the structures' foundation and bearing walls would be required. This detailed investigation would provide critical information in determining the structural ability of each building to withstand the hydrostatic pressure encountered during a flood as well as structural modifications that may be required in order to attach framing for the closures to each structure.

Specific Study Areas and Improvement Plans

In the following analysis of the 8 specific study areas, individual damage centers in each town were examined in terms of floodplain activities, floodplain characteristics, recurring losses and annual losses. Benefits were estimated for each local plan of improvement, both structural and nonstructural, and a benefit/cost ratio and net benefits were calculated for each.

(1) RUMFORD (VIRGINIA), ME.

In the Virginia area of Rumford a total of 34 structures, 22 residential and 12 commercial were identified as floodprone. From the recurring losses table below it can be seen that significant flood losses begin at events approaching the 50 year flood. The majority of structures have first floors at or below the 100 year flood level and flood entry points well below the 100 year level.

TABLE 17
Recurring Losses - By Event

	10 Year	50 Year	100 Year	500 Year	Annual Losses
Rumford (Virginia)	$144,200	$1,227,500	$1,622,000	$2,015,200	$98,800

The structural alternative formulated to reduce the flood loss potential in this area is a dike plan evaluated at the 50 and 100 year levels of protection. Two nonstructural plans were formulated. The first involved the raising of the first floor of 3 residential structures to one foot above the 100 year flood level. The second is to install closures to seal openings in 20 residential and 10 commercial structures to protect against the 100 year flood.

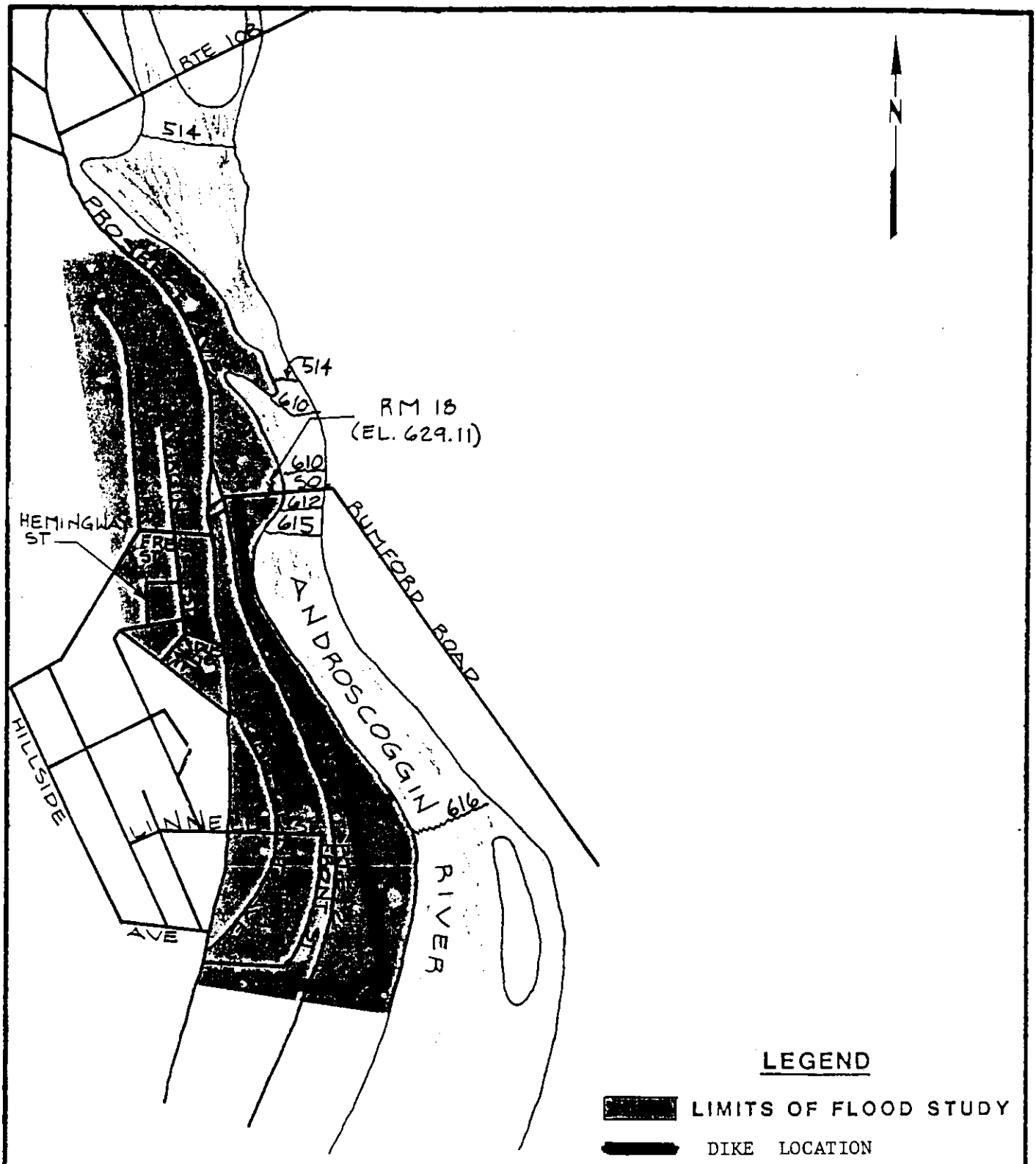
TABLE 18
Structural Improvement Plan - Rumford

	Dike - 50 year prot.	Dike - 100 year prot.
Annual Benefits	$76,100	$84,000
Capital Cost	$1,167,000	$1,392,000
Annual Costs	104,000	124,000
Benefit/Cost Ratio	.73 to 1	.68 to 1
Net Benefits	---	---

TABLE 19
Nonstructural Improvement Plans - Rumford

	Raising (3 bldgs)	Closure (30 bldgs)
Annual Benefits	$1,100	$57,400
Annual Costs	8,200	64,600
Benefit/Cost Ratio	.13 to 1	.88 to 1
Net Benefits	---	---

From the above tables can be seen that both the structural and nonstructural plans have benefit/cost ratios below unity and therefore are not justified on economic grounds.



Group J

RUMFORD (VIRGINIA)

Figure 18

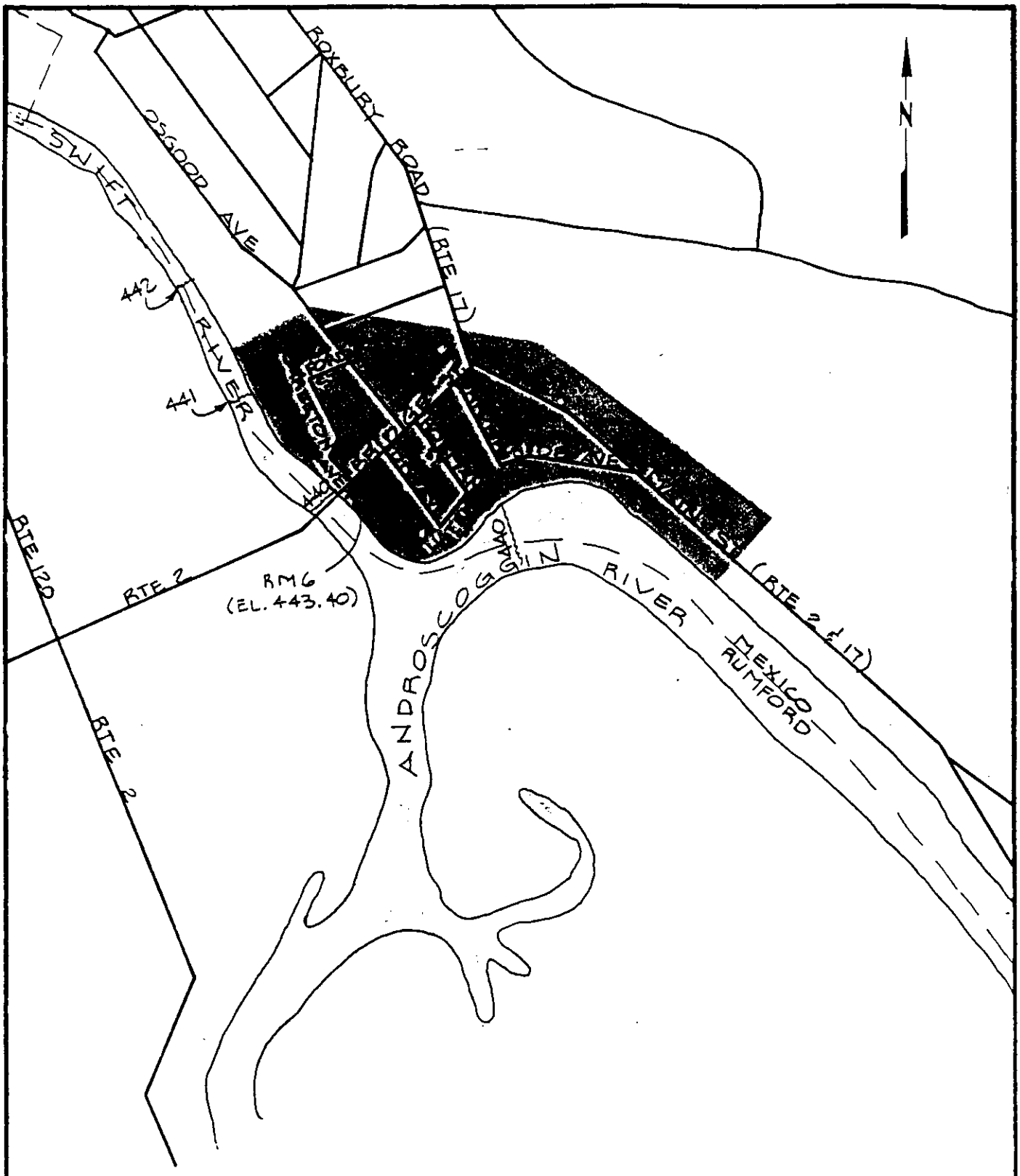

ROXBURY ROAD (RTE 17)
OSGOOD AVE
SWIFT
442
441
RIVER
RTE 120
RTE 2
RMG
(EL. 443.40)
ANDROSCOGGIN RIVER
MEXICO
RUMFORD
(RTE 2 & 17)
N
LEGEND
LIMITS OF FLOOD STUDY
Group H
MEXICO

Figure 19

(2) MEXICO, ME.

The damage center in Mexico is located in an area adjacent to the confluence of the Swift and Androscoggin Rivers. Of 71 total structures, the majority are residential (55), with the remainder commercial (14) and public (2). All but 4 of the structures have first floor elevations above the 100 year flood level. This fact explains why significant recurring losses do not occur until the 100 year and rarer events and also why expected annual losses are relatively low at $500 per structure an average.

TABLE 20
Recurring Losses - By Event

	10 Year	50 Year	100 Year	500 year	Annual Losses
Mexico	$8,500	$383,600	$748,700	$3,914,600	$35,400

Structural plans were not formulated because the low level of annual losses to be prevented would make economic justification highly doubtful. Nonstructural plans consisted of (i) raising the first floor of 7 residential structures and (ii) providing closures for all 71 structures in the Mexico damage center.

TABLE 21
Nonstructural Improvement Plans - Mexico

	Raising (7 bldgs)	Closures (71 bldgs)
Annual Benefits	$2,900	$11,100
Annual Costs	28,700	100,000
Benefit/Cost Ratio	.10 to 1	.11 to 1
Net Benefits	---	---

(3) PERU/DIXFIELD, ME.

Only 11 structures exhibit existing flood loss potential in the Peru/Dixfield area. There are 7 residential structures, 1 commercial, 1 public and 2 industrial (factory) buildings. With the exception of 2 residences all of the structures have first floor elevations below the 100 year flood level. The main factory building, located off Hammonds Ferry Road in Peru, has a first floor elevation 10 feet below the 100 year flood level. This one structure accounts for 90 percent of 10 year event recurring losses and 50 and 40 percent respectively of 50 year and 100 year total recurring losses.

TABLE 22
Recurring Losses - By Event

	10 Year	50 Year	100 Year	500 Year	Annual Losses
Peru/Dixfield	$75,500	$307,600	$387,500	$601,900	$31,100

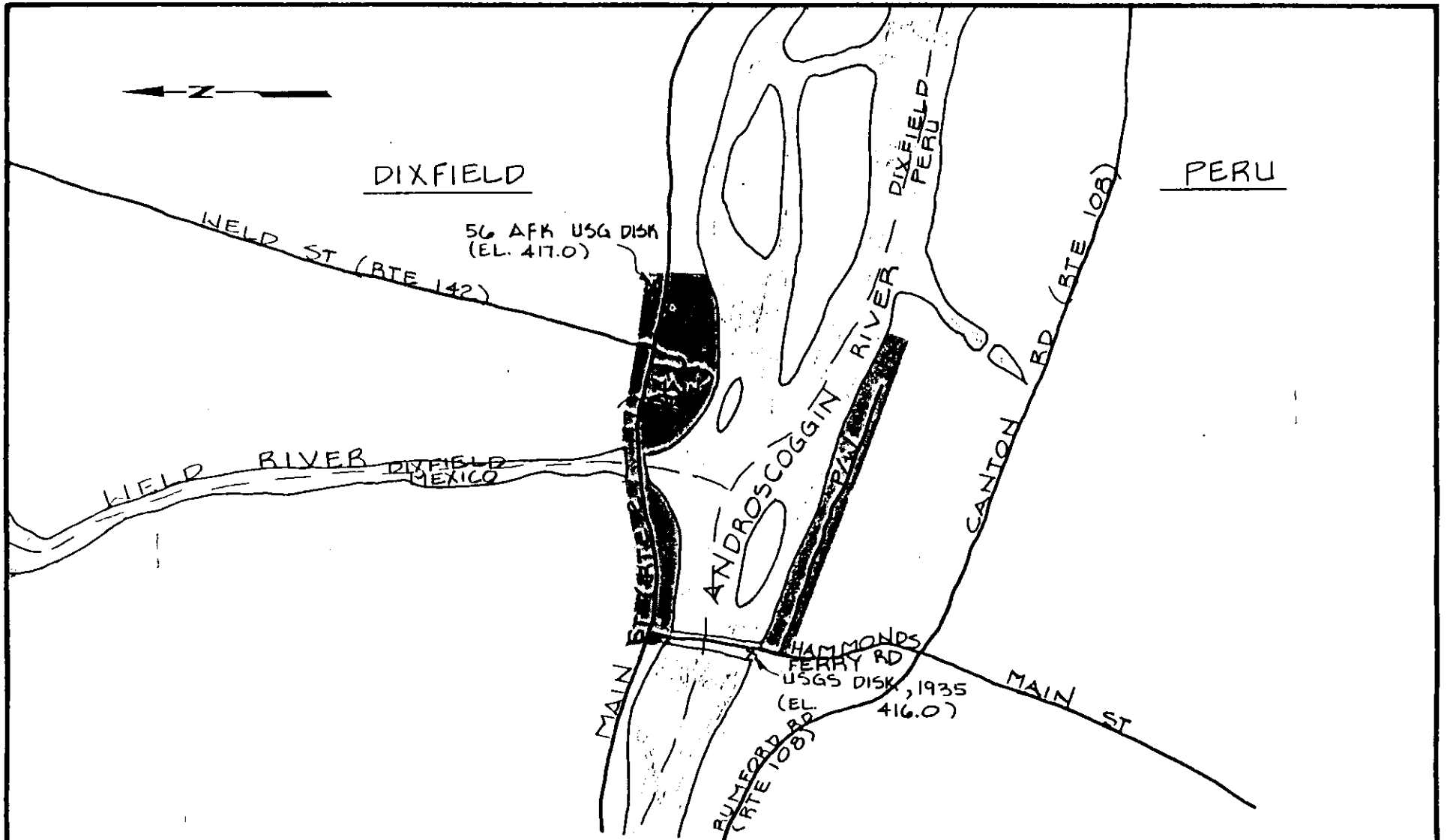
No structural plans of improvement were formulated for this area due to the geographical dispersion of the properties and the relatively low amount of total annual losses which would make economic justification doubtful. The one nonstructural plan formulated provides closures for the openings of all 11 structures in the damage center.

TABLE 23
Nonstructural Improvement Plan - Peru/Dixfield

	Closures (11 bldgs)
Annual Benefits	$17,400
Annual Costs	40,200
Benefit/Cost Ratio	.43 to 1
Net Benefits	---

(4) CANTON, ME.

The damage center in Canton consists of 16 residential structures located along Canton Point Road and Route 140. Twelve of the structures have first floor elevations above the 100 year flood level which accounts for the incidence of significant recurring losses only at the rarer events.



LEGEND

LIMITS OF FLOOD STUDY

Group F

PERU AND DIXFIELD

Figure 20

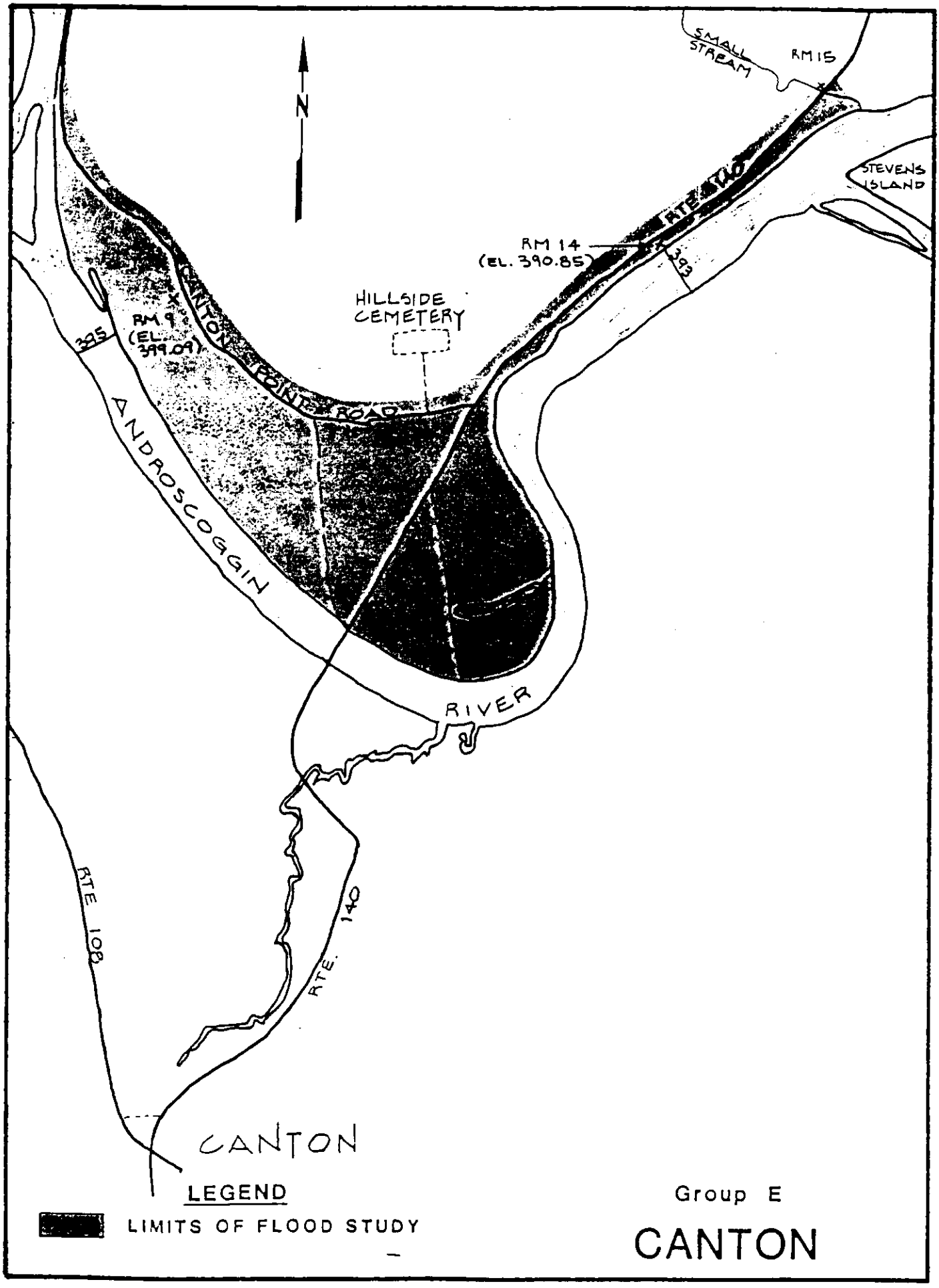
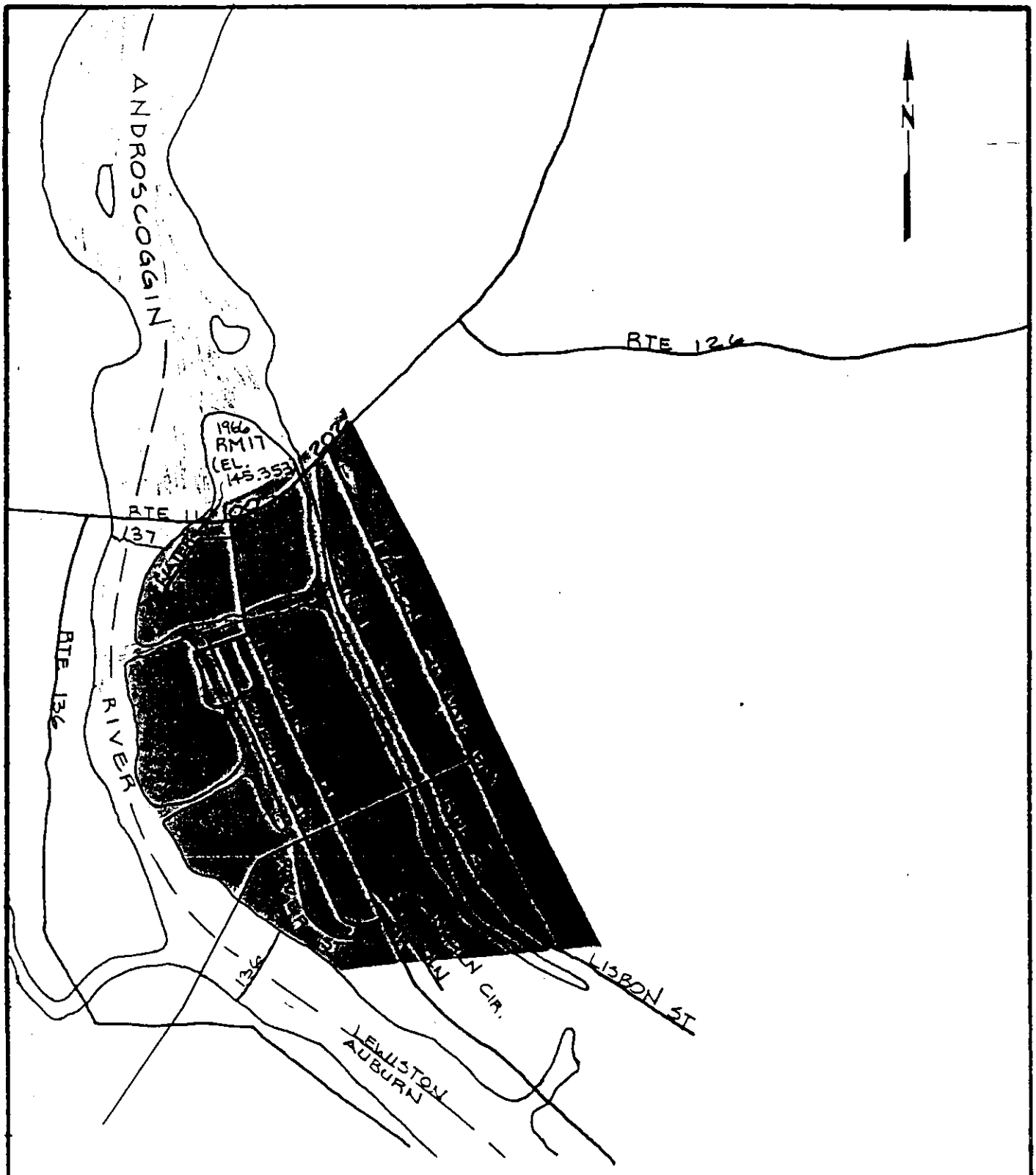

N
SMALL STREAM
RM 15
STEVENS ISLAND
RTE 140
RM 14
(EL. 390.85)
393
HILLSIDE CEMETERY
RM 9
(EL. 399.09)
395
CANTON POINT ROAD
ANDROSCOGGIN
RIVER
RTE 108
RTE. 140
CANTON
LEGEND
LIMITS OF FLOOD STUDY
Group E
CANTON

Figure 21



LEGEND

LIMITS OF FLOOD STUDY

Group A

LEWISTON

Figure 22

TABLE 24
Recurring Losses - By Event

	10 Year	50 Year	100 Year	500 Year	Annual Losses
Canton	$48,600	$193,000	$247,000	$736,000	$20,300

No structural improvement plan was formulated for Canton due to the dispersed location of the houses and the low level of average annual losses. The nonstructural plan provides for installation of closures for the openings of 10 of the structures.

TABLE 25
Nonstructural Improvement Plan - Canton

	Closures (10 bldgs)
Annual Benefits	$11,400
Annual Costs	7,500
Benefit/Cost Ratio	1.5 to 1
Net Benefits	$3,900

(5) LEWISTON, ME.

The damage center in Lewiston is a concentrated area bordered by the Androscoggin River, Route 202 and Lisbon St. There are 109 structures which exhibit flood damage potential, of which the majority (95) are residential and the remaining 14 are commercial. The residences range from 1-story single family homes to 4-story multi-unit apartment buildings. Of the 109 structures, 76 percent have first floors at an elevation above the 100 year flood level. On a cumulative basis recurring losses do not become significant until the 50 year flood level and beyond. This fact also accounts for the relatively low total of expected annual losses versus the number of structures.

TABLE 26
Recurring Losses - By Event

	10 Year	50 Year	100 Year	500 Year	Annual Losses
Lewiston	0	$567,200	$1,006,400	$2,991,500	$43,100

No structural plan of improvement was formulated for Lewiston based on the low level of annual losses. It is highly doubtful that prevention of this amount of annual losses could justify economically the appropriate protective structures based on the size of the area and the existence of canals running through it. Nonstructural plans formulated for the Lewiston damage center are (i) raising the first floors of 8 residences and (ii) providing closures for 94 residential structures and 11 commercial structures.

TABLE 27
Nonstructural Improvement Plans - Lewiston

	Raising (8 bldgs)	Closures (105 bldgs)
Annual Benefits	$1,100	$16,400
Annual Costs	16,400	107,300
Benefit/Cost Ratio	.07 to 1	.15 to 1
Net Benefits	---	---

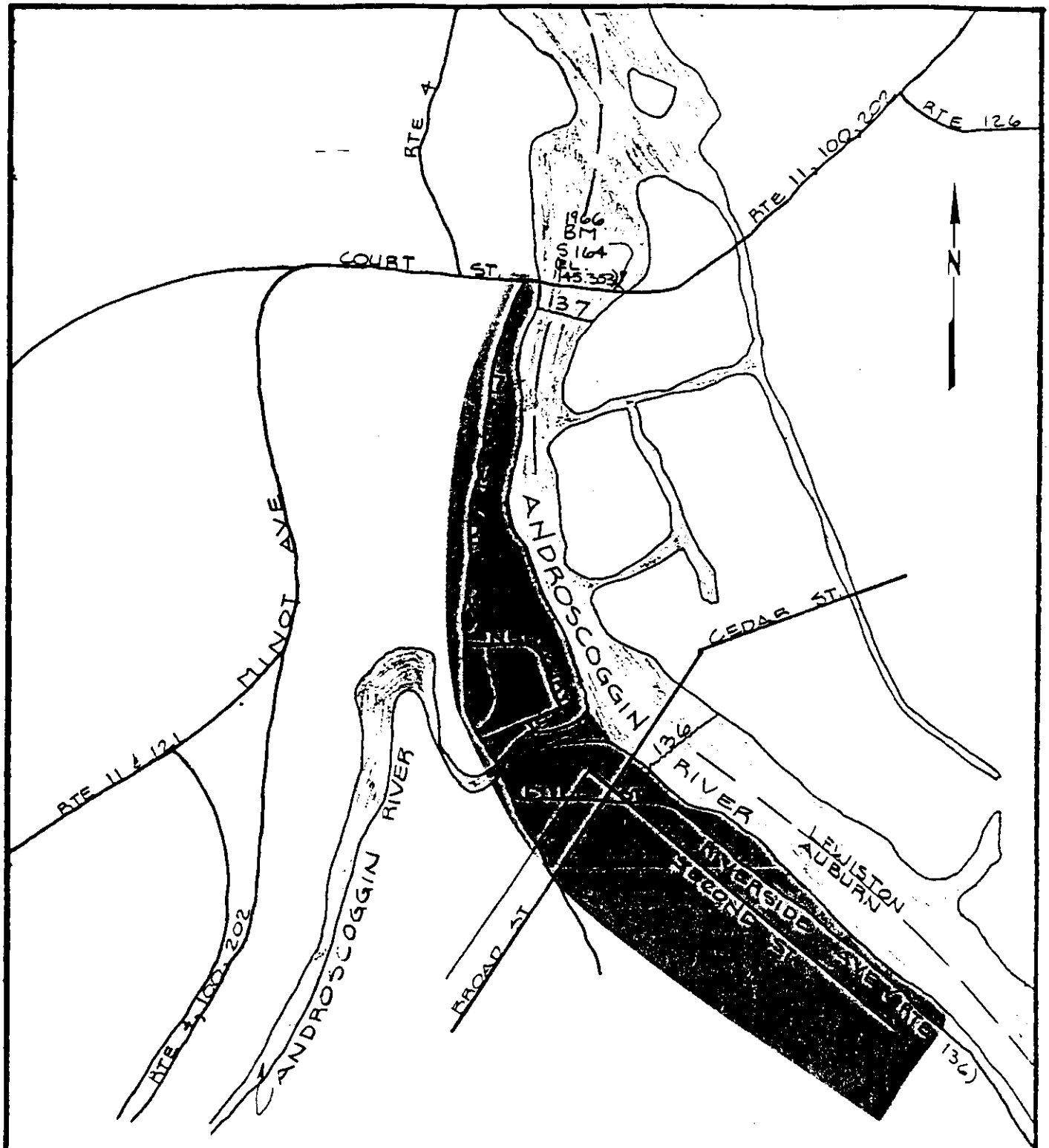
(6) AUBURN, ME.

There are 65 structures in the damage center of Auburn, one-third of which are commercial (21) and the remaining two-thirds are residential (44). The buildings are strung out alongside the river on Main St., Newbury St., and Riverside Ave. Twenty-eight of the 65 structures have first floor elevations below the 100 year flood level and significant damages begin after events greater that the 20 year flood.

TABLE 28
Recurring Losses - By Event

	10 Year	50 Year	100 Year	500 Year	Annual Losses
Auburn	$25,000	$318,800	$780,800	$3,992,200	$38,900

Structural improvement plans were not formulated for the Auburn damage center due to its dispersed geographical nature and the relatively lower level of annual losses. Nonstructural plans include (i) raising the first floor of 11 residences and (ii) providing closures for 41 residential structures and 21 commercial structures.



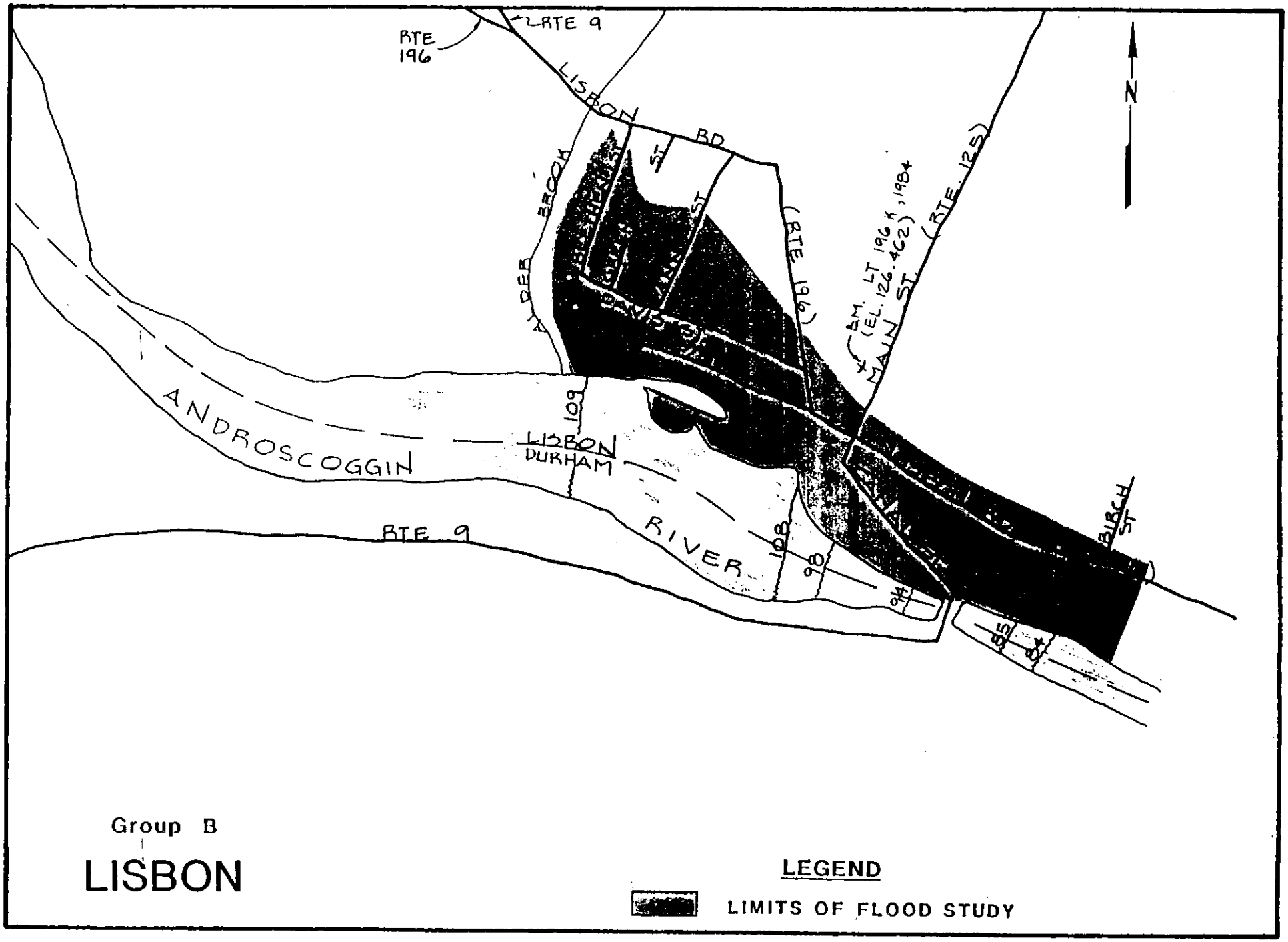
LEGEND

LIMITS OF FLOOD STUDY

Group C

AUBURN

Figure 23



Group B

LISBON

LEGEND

LIMITS OF FLOOD STUDY

Figure 24

TABLE 29
Nonstructural Improvement Plans - Auburn

	Raising (11 bldgs)	Closures (62 bldgs)
Annual Benefits	$5,500	$10,000
Annual Costs	45,200	130,100
Benefit/Cost Ratio	.13 to 1	.08 to 1
Net Benefits	---	---

(7) LISBON, ME.

The damage center in Lisbon is comprised of 2 commercial structures which house 5 activities, 27 mobile homes, 8 wooden residences and 1 brick municipal structure. One half of the structures have first floor elevations 1 to 2 feet above the 100 year flood level while the other one-half have first floors at or 1 foot below the 100 year level. For this reason, flood losses do not approach the significant level until the 50 year event and beyond. Flood losses also do not increase dramatically with higher stages due to the value of the properties and the minor increase in flood stage between events. For example, there is only a 3 foot increase in flood stage between the 10 year and 100 year events. These facts also account of relatively low annual losses.

TABLE 30
Recurring Losses - By Event

	10 Year	50 Year	100 Year	500 Year	Annual Losses
Lisbon	$46,100	$119,300	$147,800	$518,200	$18,900

Due to the dispersed locations of the floodprone properties and the low level of annual losses structural improvement plans were not formulated for Lisbon. Nonstructural plans formulated include (i) raising the first floor of 1 wooden residential structure and 22 mobile homes and (ii) providing closures for 8 wooden residences, 22 mobile homes, 2 commercial structures and one brick municipal structure.

TABLE 31
Nonstructural Improvement Plans - Lisbon

	Raising (23 bldgs)	Closures (33 bldgs)
Annual Benefits	$8,400	$12,100
Annual Costs	96,600	24,000
Benefit/Cost Ratio	.09 to 1	.5 to 1
Net Benefits	---	---

(8) TOPSHAM, ME.

The only area in Topsham which exhibits any potential for flood damages is Old Main St. which is actually an island, reached by bridge, in the Androscoggin River. There are 7 wooden industrial buildings on Old Main St. All have first floors well above, 13 to 17 feet above, the 100 year flood level. However, 2 of the structures do have low water entry points near the 100 year flood level; the other 5 do not. Recurring losses therefore reflect damage at only two structures.

TABLE 32
Recurring Losses - By Event

	10 Year	50 Year	100 Year	500 Year	Annual Losses
Topsham	0	0	$54,400	$163,000	$1,500

The low level of annual losses precluded the formulation of structural alternatives. A nonstructural plan was explored for one of the buildings in terms of a closure but with flood losses beginning at the 100 year event, benefits amounted to less that $200 annually and the plan was not economically justified.

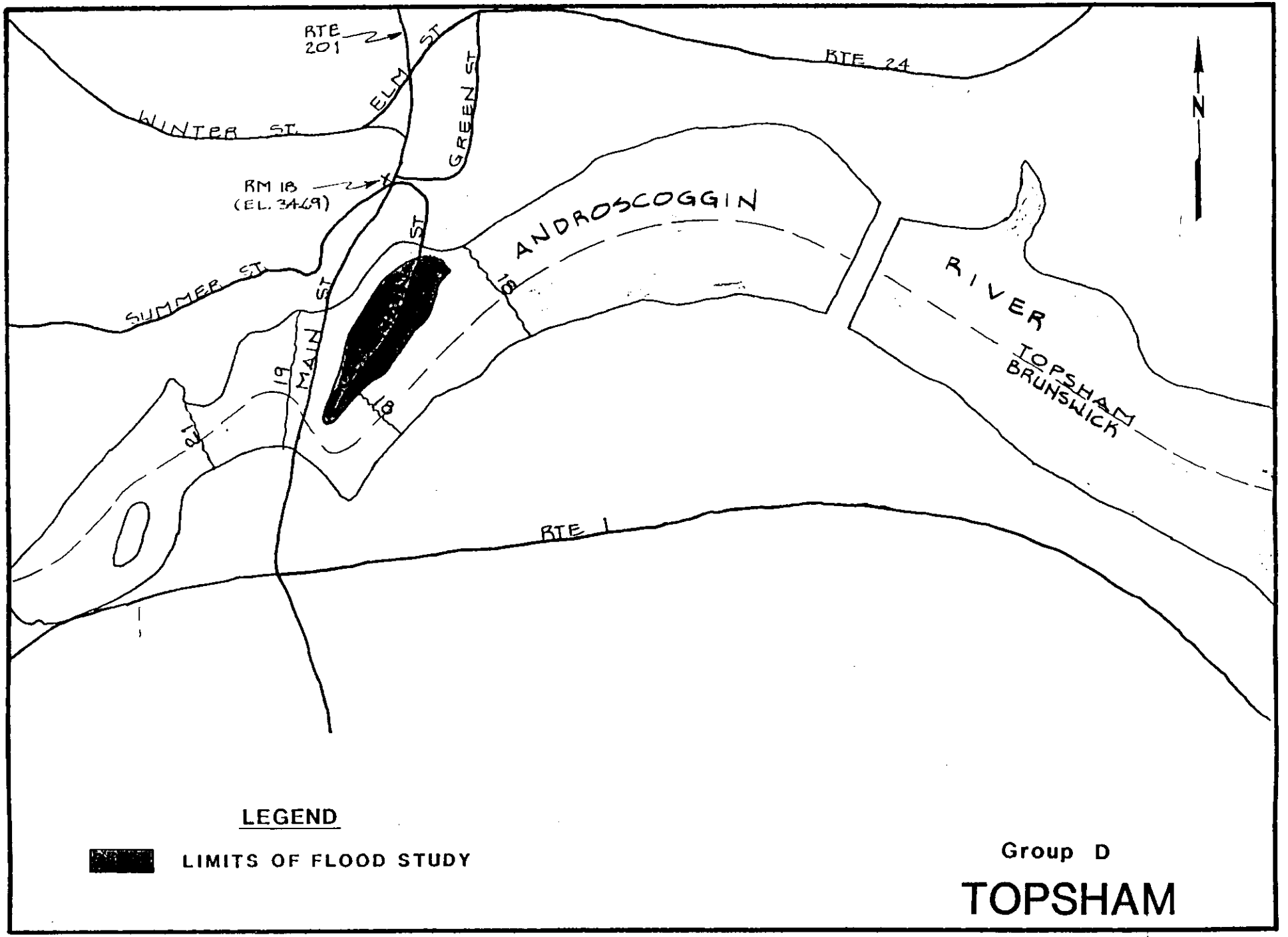

RTE 201
ELM ST
GREEN ST
RTE 24
WINTER ST
RM 18
(EL. 34.69)
SUMMER ST
MAIN ST
ANDROSCOGGIN
RIVER
TOPSHAM
BRUNSWICK
RTE 1
N
LEGEND
LIMITS OF FLOOD STUDY
Group D
TOPSHAM

Figure 25

Automated Flood Warning System

An automated flood warning system consists of a series of remotely-located precipitation and/or stream flow gages that report to a computer. The computer gives information on predicted peak flood stage and the time to the peak stage. This information, through the application of a preparedness plan, can be translated into what would be expected to occur at individual communities in the Androscoggin River Basin. Flood warning is not a solution to flooding; it can help reduce damages and potentially save lives.

Benefits which accrue to an automated flood warning system are based on the relationship between forecast lead time and associated reduction in damages. The underlying assumption is that people receive the flood warning, heed it, and take appropriate steps to reduce potential damages. A preliminary analysis which utilized an existing relationship, in the form of a curve, between forecast lead time and percent reduction in damages was employed. The relationship from Day et al (1969) was used in the 1984 Passaic River Basin Study, New York and New Jersey, and appears to be appropriate for the purpose of this study. The maximum forecast lead time from Day is 48 hours and the corresponding maximum percent reduction in damages is 35 percent. For the Androscoggin Basin average forecast lead time is 12 hours and the corresponding reduction in damages is 22 percent. The total benefit for the 9 towns in the basin is $63,400, as shown in Table 34.

TABLE 34

Town	Benefits - Flood Warning System
Rumford	$21,700
Mexico	7,800
Peru/Dixfield	6,800
Canton	4,500
Lewiston	9,500
Auburn	8,600
Lisbon	4,200
Topsham	300
TOTAL:	$63,400

The first cost of an automated forecasting and warning system for the Androscoggin basin is shown in table 35.

TABLE 35

Component	Quantity	Cost
Precipitation Gages	20	$160,000
Stream Flow Gages	4	20,000
Computers	1	20,000
Communications (repeaters)	4	32,000
Sub-Total		232,000
20 % E&D		46,000
TOTAL		$278,000

Using an amortization period of 15 years, and a rate of 8 7/8%, the annualized first cost is $29,100. Annual operation and maintenance is estimated at 10% of the initial equipment cost, equal to $23,000. Total annual cost is therefore $52,100.

The economic justification of the Automated Flood Warning System is as follows.

	Flood Warning System
Annual Benefits	$63,400
Annual Costs	$52,100
Benefit/Cost Ratio	1.21 to 1.
Net Benefits	$11,300

Reservoir Reregulation

Most of the existing flood storage in the basin is located in the Rangely Lakes (upper basin) area. As previously discussed, that storage is currently being managed by Union Water Power Company (UWPC). Although their operating criteria are weighted toward hydroelectric power generation (subject to minimum releases), those objectives are not unalligned with those of flood control. Consequently, the flood storage which is controllable, is already being controlled.

However, the possibility remains, that with more and/or more timely data on rainfall, snow cover, and flows, more effective flow regulation is possible. Such an expanded data set would be available in conjunction with an installed and operated automated flood warning system. The additional data points and computer projections associated with such a system would allow for a "fine-tuning" of existing basin storage.

Summary of Economic Analysis

The status of economic justification for all plans evaluated for all the basin cities and towns is exhibited in Table 36.

TABLE 36
Summary of Economic Justification

	Annual Benefits	Annual Costs	Benefit/Cost Ratio	Net Benefits
Rumford:				
Dike-50 yr.	$84,000	$124,000	.68 to 1	-
Dike-100 yr.	76,000	104,000	.73 to 1	-
Raisings	1,100	8,200	.13 to 1	-
Closures	57,400	64,600	.88 to 1	-
Mexico:				
Raisings	2,900	28,700	.10 to 1	-
Closures	11,100	100,000	.11 to 1	-
Peru/Dixfield				
Closures	17,400	40,200	.43 to 1	-
Canton:				
Closures	11,400	7,500	1.5 to 1	$3,900
Lewiston				
Raisings	1,100	16,400	.07 to 1	-
Closures	16,400	107,300	.15 to 1	-
Auburn				
Raisings	5,500	42,500	.13 to 1	-
Closures	10,000	130,000	.08 to 1	-
Lisbon				
Raisings	8,400	96,600	.09 to 1	-
Closures	12,100	24,000	.5 to 1	-
Topsham				
Closures	<200	-	-	-
Basinwide Automated Flood Warning System	$63,400	52,100	1.21 to 1	$11,300

CONCLUSIONS & RECOMMENDATIONS

CONCLUSIONS

The Androscoggin River experienced a major flood in March/April 1987, resulting in serious property loss and business interruption that occurred along the main stem from Rumford to Brunswick, ME. Communities within the New Hampshire portion of the basin were spared major damage, with the five upper-basin lakes exercising their flow attenuation function, while the bulk of the rain and snow-melt hit the mid-basin.

Flood Control Reservoirs

No new flood control sites were evaluated in the basin. A HEC-1 model of the basin, calibrated to reproduce the 1987 flood event, allowed simulation of flood storage at various points in the basin, and subsequent measurement of peak flow reduction at the damage centers. The findings of these analysis confirmed those of prior studies...i.e., that no cost-effective reservoir sites were found. The Pontook site, in Dummer New Hampshire, which showed promise in earlier Corps of Engineers studies, was no longer economically viable.

Local Protection Projects

Local protection projects were evaluated for nine flood damage centers, by way of a screening analysis. The results indicated that only one project, Rumford, ME, warranted a more intense evaluation. Subsequent investigation found that the project was not economically justified.

Automated Flood Warning System

Results of this investigation show that benefits associated with an automated flood warning system are sufficient to justify such a project. An economic evaluation resulted in a benefit to cost ratio of 1.21 to 1.

Reservoir Reregulation

Additional analysis is required to quantify the benefits of additional data points and computer models (associated with automated flood warning systems) toward improved storage management in the interests of flood control, hydroelectric power output, and water quality.

Nonstructural Measures

Nonstructural measures involving raising structures and installing closures, were evaluated at all of the principal damage centers. There are cost-effective opportunities in at least one of the damage areas for these strategies. Since the damage centers were selected using a "major" screening criteria, there is reason to believe that there may be other instances, in other communities, where there is positive payback to these measures. It is also concluded that the possibility exists that nonstructural measures would be economically feasible when lower levels of protection (for greater frequency events) then the 100-year level are analyzed.

RECOMMENDATION

The results of this study indicated that further investigations could be accomplished under the existing Continuing Authorities Program. I, therefore, recommend that no further work be conducted in the Androscoggin River Basin under this General Invesigation Authority.

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DATE

DANIEL M. WILSON
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